DOCUMENT RESUME

ED 068 357 SE 014 968

TITLE	Planning for Integrated Science Education in Africa. Report of a Regional Workshop.
INSTITUTION	United Nations Educational, Scientific, and Cultural Organization, Paris (France).
PUB DATE	71
NOTE	71p.; Report of the Workshop for Science Education Programme Planners in English-speaking African countries, Ibadan, Nigeria, Sept. 20 - Oct. 4, 1971.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Conference Reports; *Developing Nations; *Educational Strategies; International Education; *Leadership Training; *Science Education; Science Laboratories; Science Materials; Teacher Workshops; Workshops
IDENTIFIERS	UNESCO

ABSTRACT

This report of a workshop held in Nigeria for the leaders of science education at primary and lower secondary levels in 15 African nations describes the status of science instruction in those countries. The workshop was sponsored by UNESCO/UNICEF and continued from September 20th through October 4th, 1971. The main address to the conference, entitled, "Premature Specialisation in Science Education: A Disservice to Developing Nations," is included in the appendix. The chapter on "The Present Situation in Integrated Science Teaching in African Countries" is a compilation of information gathered from all the 15 nations. The emphasis of the workshop was on reviewing the progress of integrated science teaching programs in African nations and planning strategies for future work. Other topics included a review of programs outside Africa and a general plan for collaboration among participating African nations. The discussions centered on curriculum planning for integrated science teaching; science materials, equipment and facilities; teacher education; and evaluation. Separate chapters are devoted to each of these topics in the report. (PS)

ED 068357

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY

ERIC
Full Text Provided by ERIC

ERIC
Full Text Provided by ERIC

ED 068357

Planning for Integrated Science Education in Africa

Report of the Workshop for Science
Education Programme Planners in
English-speaking African countries.
Ibadan, Nigeria
Sept. 20th—Oct. 4th, 1971.

UNESCO-UNICEF Co-operation in Integrated
Science Education

ERIC

Published by UNESCO

The contents of this publication represent the views of the participants at the Workshop for Science Education Programme Planners in English-speaking African countries; they do not necessarily reflect the official position of UNESCO. The photographs used were taken in Nigeria by Mr. N. K. Lowe.

PRINTED BY ASSOCIATED PRESS OF NIGERIA LIMITED

ERIC

CONTENTS

I INTRODUCTION

The Workshop 'Planning for Integrated Science Education in Africa' was held at the Conference Centre, University of Ibadan, by invitation of the Government of Nigeria, from September 20th to October 4th, 1971. It was sponsored jointly by UNESCO and UNICEF, following Programme Resolution 2.21 adopted by the General Conference of UNESCO at its sixteenth session. The Workshop was attended by national participants from fourteen African countries, who were science education specialists concerned with developing programmes of integrated science education at the primary and lower secondary levels. It was also attended by invited consultants, UNESCO experts in science education associated with UNESCO/UNICEF project in African countries, observers from bi-lateral aid organizations and UNESCO staff members from the UNESCO field Science Office for Africa, Nairobi, the Regional Educational Buildings Research Institute for Africa, Khartoum, and UNESCO Headquarters.*

The Workshop was the second of two meetings for English-speaking African countries sponsored jointly by UNESCO and UNICEF. It followed the guidelines developed at the first meeting for policy–makers, which was held in Nairobi in July 1971, and embodied in the report "Education for Rural Development in Africa." **

The objectives of the Workshop were:

1. To exchange information on current projects and programmes aimed at the production and implementation of integrated science curricula in English-speaking African countries.
2. To review integrated science teaching programmes from outside Africa which might be used as resources in developing programmes for African countries.
3. To make suggestions for the development of integrated science teaching programmes, including teaching approaches and methodology, learning materials (printed materials, equipment, teaching aids, etc) teacher training (pre-service, in-service and continuing education of teachers) and other relevant considerations.
4. To draw up a plan for collaborative action among participating countries.

The level of work discussed at the Workshop covered the teaching of science in an integrated approach during the first eight or nine years of schooling.

Activities during the workshop included talks and discussions in plenary sessions, visits to places of educational interest and displays of printed materials, audiovisual material and science teaching equipment. Four working groups were established on the subjects of curriculum planning, teaching materials and facilities, teacher education, and evaluation. Working group A, which was concerned with curriculum planning followed the Nairobi Seminar recommendation that "the Workshop at Ibadan should spell out a clear concept of what integrated science includes within the framework of health, agriculture, nutrition etc. vis-a-vis the basic sciences of biology, chemistry and physics or general science where these are taught together." *** It also drew up a guide for curriculum planning for integrated science teaching in a hypothetical African country, and constructed a specimen lesson. Group B was concerned with science teaching materials and facilities including printed materials, audio visual materials, and science equipment. It also drew up specifications for a prototype inter-

* For list of participants, see Annex 1
** Report obtainabe from the UNESCO Field Science Office for Africa, Nairobi, Kenya.
*** Nairobi Seminar Report, P.57

greted science teaching laboratory. Group C was concerned with teacher education for integrated science teaching following the Nairobi Seminar recommendation that "the Workshop must isolate the implications of integrated science teaching relating to the training of teachers."* It covered pre- and in-service training and further education of teachers, including the work of science teachers' associations. It also produced specimen teaching materials for orienting teachers in service or in training towards an integrated approach to their teaching. Group D was concerned with evaluation and testing. The recommendations from these four working groups are embodied in the report and form chapters III, IV, V and VI of the report, respectively. The plan for collaborative action, which forms chapter VII of the report, is drawn up from proposals and suggestions put forward by the working groups and in plenary sessions.

The Workshop was opened by Mrs. F. M. Akintunde—Ighodalo, Permanent Secretary, Western State of Nigeria Ministry of Education. Addresses of welcome were also given by Professor G.M. Edington, Deputy Vice-Chancellor of the University of Ibadan, and Dr. N. S. Rajan, UNESCO Chief of Mission in Nigeria. A message of welcome was read out from Chief S. O. Awokoya, Director, Department of Science Teaching and Technological Education and Research, UNESCO. The Key-note address to the Workshop was given by Professor A. Babs Fafunwa, Deputy Vice-Chancellor, University of Ife, Nigeria. The co-chairmen of the Workshop were Mr. J. M. Akintola, Federal Ministry of Education, Nigeria, and Mr. T. A. Balogun, Faculty of Education, University of Ibadan. The Organizing Committee for the Workshop established under the auspices of the Nigerian National Commission for UNESCO consisted of Mr. J. F. Olagbemi, Mr. J. A. Akintola, Mr. A. Osiyale, Rev. F. S. Samuel, Mr. R. S. G. Agiobu Kemmer, Dr. E. A. Yoloye, Mr. F. Oyewole, Mr. C. N. Sharma, Mr. N. K. Lowe, and Mr. L. E. Folivi, who also acted as Workshop Co-ordinator. Workshop Liason was carried out by Mr. S. M. Winsala, Conference Officer, University of Ibadan.

* For list of participants, see Annex I

II THE PRESENT SITUATION IN INTEGRATED SCIENCE TEACHING PROGRAMMES IN AFRICA

The material for this chapter is based on country reports submitted by the representatives from the following countries: Botswana, Ethiopia, Gambia, Ghana, Kenya, Lesotho, Liberia, Mauritius, Nigeria, Sierra Leone, Somalia, Tanzania, Uganda, and Zambia. It is augumented by written reports, syllabuses and other background material available at the workshop for reference purposes. What follows is not an authoritative and comprehensive account, supported by statistics, of the status of science education in the 14 countries represented at the workshop, but rather a general account of trends towards integrated science teaching in the respective countries, with more detailed descriptions of particular projects in a few of the countries. A summary is given at the end of the chapter.

Although there are many different educational systems across the continent of Africa, there appear to be a number of problems that most countries have in common. There are also several co-operative attempts to develop programmes of science education at primary and secondary level, that are common to a number of countries. Throughout Africa there is a genuine desire to relate education at school more closely to community or rural development, but the difficulties of putting this philosophy into practical terms are often very great.

Among the common features of educational systems in Africa are the variations within countries of the percentage of children receiving primary education, from something approaching 100 per cent in major cities to less than 10 per cent in remote areas. There is also the common problem of drop-out from the primary grades; this often means that fewer than 50 per cent of those who begin primary education will reach the end of that phase. Then there is the spectre of the primary school leaving examination and/or the entrance examination to secondary schools that have such a profound effect on the curriculum, particularly in the upper forms of primary school. This especially effects the teaching of science, as science is not normally one of the subjects examined for the award of the primary school leaving certificate; the subject thus tends to be neglected for obvious reasons. Another important factor is the medium of instruction. While often this is English—at least in the upper forms of the primary school—English is rarely the mother tongue of individual children.

Even in those countries, such as Tanzania and Ethiopia, which have introduced a vernacular as the medium of instruction in primary schools, the chosen vernacular may not be the mother tongue of all children in the school, owing to the plurality of regional and local languages and dialects in many African countries. And even when a vernacular language is the medium for primary education, there is still the problem of transition to English language at the secondary or post-secondary stage.

Thus there are many problems—and many of them common problems—for which a variety of solutions are being tried. All countries are giving particular attention to in-service training as a means of introducing new ideas for the teaching of science and of upgrading poorly qualified or unqualified teachers. Associated with such efforts are a number of curriculum development centres and key institutions for teacher training. The former often exercise the role of coordinating development as well as functioning as nuclei of centres for generating new materials, including simple prototype equipment.

Primary Education

In general, science is taught in African primary schools, if at all, in an undifferentiated way.

That is to say it is not taught under the familiar separate headings of chemistry, physics or biology. Nor is it usually taught by specialist teachers, and certainly not so in the first four grades. It is, however, often designated as "nature study", "health science" or "rural science".

In several countries, modern "activity centered" approaches are being introduced. The instrument of change in most of these cases, is the African Primary Science Programme (APSP) which, from 1970, has become the Science Education Programme for Africa (SEPA). The origin of the APSP can be traced back to the fifth Rehovoth Conference in Israel in 1960 and also, to the efforts of Professor Babs Fafunwa in the University of Nigeria, Nsukka, to establish a science programme in 1962. But the real beginning of the APSP stemmed from a Pan-African conference on science education held in Kano, Nigeria in 1965. The programme was guided by a Steering Committee, composed mainly of Africans, and funded by the Education Development Centre of the U.S.A. (formerly called Educational Services Incorporated). The handing over of responsibility to SEPA in 1970 was both a fulfilment of the original objective to place the direction and administration of the APSP in African hands, and a recognition of the fundamental African nature of the APSP.

The general objective of SEPA is to promote excellence in the learning of science at all levels of education in Africa. This subsumes three earlier aims—to promote effective ways of learning science by utilising the child's environment, to develop and to introduce new and relevant science curriculum materials into African schools, and to establish institutions in Africa concerned mainly with the furtherance of the renewal of science curricula.

In pursuance of the aim to develop curriculum materials, more than 50 teachers guides and children's books have been printed. These range from the first to be produced as a result of a writing conference at Entebbe Uganda in 1966—'Ask the Ant Lion'—though other units dealing with the biological environment such as 'Mosquitoes' and 'Chicks in the Classroom', to units concerned with the universe such as 'Strangers in the Sky' and 'Moon Watchers'. They also include units on the physical environment such as 'Wet Sand', 'Dry Sand', Inks and Paper', 'Torch Bulbs and Batteries' and 'Making Things Look Bigger'. A list of units currently available may be found in 'A Teachers' Guide to the African Primary Science Programme' published by the Njala Science Curriculum Development Centre, Njala University College, Private Mail Bag, Freetown, Sierra Leone. In addition a few films have been produced showing some of the units in use in actual classroom situations.

The main concern of SEPA is to provide meaningful learning experiences for the child. The study of science is regarded as one of the most valuable means of furthering his development by providing opportunities for him to explore his own environment. Children are encouraged to find things out for themselves, to see problems from varying frames of reference and to develop an ability to resolve such problems themselves. Thus they will come to realise their own strengths. They might even learn in the course of their own development to approach problems in other situations with confidence and integrity. The SEPA approach, as exemplified by the units now available, was developed during writing workshops of about 4—6 weeks duration followed by extensive trials of the materials. The materials themselves make use of familiar aspects of the child's environment (plants, animals, stones etc) which can capture and hold the attention and interest of children.

The teachers' role in this process however, is far from passive. He has to raise questions and make suggestions, he has to select appropriate materials and to appraise the children's efforts, imagination, excitement, and frustrations almost continuously. All this has profound implications for teacher education and the whole purpose of the school in its formal setting.

What then is happening in individual countries as the result of SEPA as the instrument of educational change at the primary level? **Ghana, Kenya, Nigeria, Sierra Leone and Tanzania** are the countries, represented at the Workshop, which have taken up, to a varying extent, the SEPA units and are incorporating them into the primary curricula. (It is known that Malawi is likewise involved.) Other countries such as Ethiopia and Zambia are developing their own primary science schemes, through curriculum development centres, and the writers of these schemes are drawing on some of the SEPA materials. The Gambia has recommended the use of SEPA units for the future and Liberia is planning a workshop on SEPA materials as a means of introducing some trials in 1972.

But even the countries with the most active involvement with SEPA would not claim that this approach is in use throughout the whole primary school system. In Tanzania, for instance, where the philosophy exemplified by the SEPA units is in consonance with the national aims of education, the introduction of new science schemes has, perforce, to be confined to those primary schools which are within easy access of certain "key" teachers' colleges, and in districts with enthusiastic primary school inspectors. About 10 units have been developed in Tanzania for grades one and two under the title 'Activities for lower Primary Schools' and these units describe activities that young children can do with familiar materials from their environment e.g. wet sand, tin-cans, dry sand, tubes, reeds, seeds, wheels. At the level of grades three and four the children are involved in problem-solving situations. For example the unit on 'Water, Colour and Paper involves working with colours and learning to produce a variety of colours from simple materials such as leaves, flowers, roots and barks. There are about 10 units for this age group. For primary grades five, six and seven approximately 30 units have been evolved. These units, and others still under development, are in support of the new syllabuses issued in November, 1969. There is still a long way to go but already a few schools are setting the pace for their respective communities. The major tasks of training students to become teachers and re-training teachers in service are being assisted by a Tanzania/UNICEF/UNESCO Primary Education Reform Project centered on the 10 Grade A Colleges. On the staff of each of the college involved are three itinerant tutor educators who, for the most part, have had long and distinguished experience as tutors or inspectors. Each college is the centre of inspiration for all the surrounding schools and the tutor educators are the agents who organise the reorientation of teachers to the new ideas. They retain light tutorial duties in the College, but most of their time is devoted to visiting schools individually or as a team. Each year it is planned to provide reorientation courses for some 240 teachers at each College. The tutor educators as well as Regional and District Education Officers are deeply involved in these courses. The goal is to reorientate 12,000 teachers by 1976.

In **Sierra Leone** the development of SEPA materials has been the concern of the Science Curriculum Development Centre at Njala University College. Through a system of inservice training, certain teachers have been introduced to the new materials and are now implementing an inquiry approach in their schools. Teachers' centres have been set up in the Provinces and in the Western area of Sierra Leone to provide local inservice training. The staff of the Science Curriculum Development Centre and selected experienced teachers are involved as tutors.

The Kenya Institute of Education (KIE) in Nairobi is the coordinating institution for the development to SEPA materials in **Kenya**. It has in fact, been involved with the former APSP since the development work began, having been established with assistance from the Ford Foundation in 1964. Production of simple equipment to support the units is also the responsibility of the KIE, and inservice training is provided both at KIE and at regional sub-centres. But with 6,000

ERIC

primary schools in the country there is a massive task ahead.

In Ghana all curriculum development activity in science is under the umbrella of the Project for Science Integration (PSI) in which the Ghana Association of Science Teachers (GAST) is actively involved. This arose from a decision taken at a Workshop, held in Takoradi in April 1970, sponsored by GAST in collaboration with the Ministry of Education and UNESCO. This means that all the activity of the Elementary Science Unit of the Ministry of Education in Ghana is now merged with the curriculum development activities of GAST and covers elementary and secondary schools and training colleges. Primary schools in Ghana are now using some of the SEPA units, and it is estimated that about 500 schools are involved in some way. Similarly middle schools are using SEPA materials. It is hoped that the Primary Group of PSI will develop a scheme or curriculum that embodies most of the units under trial. About 20 teacher training colleges now have good science programmes, and their tutors have been involved in workshops organised by the Elementary Science Unit. Local follow up of schools is undertaken by Regional and District Science Organisers. The Science Unit in Accra produces a quarterly Science Newsletter as a means of communication with teachers.

In Nigeria, a Primary School Project was set up as early as 1962 in the University of Nigeria at Nsukka with financial assistance from the Ford Foundation. Since then, SEPA units have been developed and tried out in some Nigerian schools, particularly in the vicinity of the towns of Lagos, Ibadan and Ife. At Ife there are two primary science advisers. A UNESCO/UNICEF project for primary school curriculum development was established in the six northern states of Nigeria in 1969. It is centered on the Ahmadu Bello University Zaria, and relies for developmental advice upon subject panels made up of people in the locality. The Nigerian Educational Research Council (NERC) has, this year, (1971) mounted a National primary school curriculum workshop. This arose directly from the recommendations of the National Curriculum Conference held in 1969. The Primary School Curriculum Workshop produced proposals for the first national curriculum for primary education in Nigeria. The materials produced at the workshop, including science teaching materials, will be released to the State Ministries of Education and to teacher training institutions for further development and implementation.

In **Zambia**, the New Zambia Primary Curriculum (NZPC) has been launched from the Curriculum Centre (formerly the English Medium Centre). This project is attempting to integrate the whole primary curriculum by means of specially written materials in English-the officially adopted medium of instruction from the first grade. A pilot experiment in English teaching began in 1966 in Grade I in 19 schools in Lusaka. Now materials are being written by the staff of the Centre in English, Mathematics, Social Studies, Science and Zambian languages, although the science side has so far suffered from a shortage of writers. More than 2000 grade I classes, 1500 grade II and 1250 grade III classes are now involved in this teaching experiment. If expansion continues at the present rate all grade I classes in the country will be using the NZPC by 1973. Already all the preservice teacher training courses are geared to preparing students to implement the new course.

Upper Primary and Junior Secondary Education

In some countries primary education extends over five years, in others six or seven. In the latter cases the top forms are often referred to as upper primary and at this level subject specialist teachers are frequently encountered. In other systems, grades six, seven and eight are referred to as the "junior secondary" level, and education at this level may be provided in special junior secondary schools or in middle schools rather than in the junior section of schools which provide a full secondary education. At this level Science is offered in all the educational systems re-

presented at the workshop, but in most countries it is either presented as the separate subjects chemistry, biology and physics (or sometimes only as one of them such as biology) or as "general science", but with the constituent subjects separately evident. In a few countries, however, new approaches to science through an integrated teaching programme are under development, and it is these which are of particular interest to this workshop.

One of the most significant aspects of the development of new science courses at this level is the important role played by science teachers' associations. Thus in **Nigeria** and **Ghana** where science teachers' associations have quite a long history and are particularly influential in national policy, it is interesting to note that schemes in integrated science teaching are already under developments. (See also page 27).

In **Botswana, Lesotho** and **Swaziland**, a new Junior Secondary Science Syllabus has been produced. This syllabus, called Introductory Science, was developed in 1967 with the help of a UNESCO adviser in Lesotho. Previously, science was offered as biology and physical science. The new syllabus is being used by some schools in all three territories but there is not yet general agreement as to the type of science best suited for the early years of secondary education in the three countries. Some confusion has been created, especially in Botswana, by the views of a variety of advisers from different agencies and different countries. However, in that country the newly-established Botswana Science Association is actively engaged in coordinated curriculum development. Although there are no published books or teachers' guides specifically aimed at the new Introductory Science syllabus the University of Botswana, Lesotho and Swaziland has, through two or three of its lecturers, and with some finance from the U.K. Centre for Educational Development Overseas (CEDO), produced draft versions of texts and workbooks to help those schools already involved in teaching the syllabus and preparing students for the Junior Certificate examination.

In **Somalia**, a unified science syllabus was introduced in 1967. This syllabus comprises topics drawn from biology, chemistry, physics, astronomy, earth science, health and nutrition. A teacher' guide was published in 1970 and pupils' texts are being prepared.

In **Ethiopia**, new curricula in science are being prepared at the science curriculum centre in Addis Ababa by a team consisting of two Ethiopian science education specialists, two British advisers and one Peace Corps Volunteer. The curricula at the secondary level are being developed from some of the East African Secondary Science Projects and materials. Teachers' Manuals for grades 6 and 7 have already been produced.

In the **Gambia**, the curriculum includes general science at the secondary level, but with a greater emphasis on biology. This is being followed in the new junior secondary schools. In the older-established secondary schools the syllabus is aimed at the requirements of the public examination (West African Examinations Council—WAEC) with general science being offered in the first three years.

In **Mauritius**, some new schools, called senior primary schools, have been built to provide a diversified curriculum of a non-academic-type extending over four years. From January 1972 these schools will be offering a course in science based upon local-environment and a practical approach. In the other secondary schools, which are of a grammar type, the Ministry of Education has recently decided to adopt integrated science for the first two years, based on the Scottish Scheme. It is intended, however, to make use of some of the units produced in the UNESCO Biology Project in Africa and to substitute these in place of certain sections of the Scottish Scheme.

A newly-formed **Sierra Leone** Association of Science Teachers is contributing to the development of ideas for the curriculum in secondary schools, particularly with reference to eleven

secondary schools and one teacher training institution which are involved in an International Development Association financial investment. A Curriculum Revision unit has been established specifically in this context, and possibilities of introducing some form of unified science at the Junior Secondary Level are being explored. At present general science is offered in the lower forms of secondary schools.

In Kenya, Uganda and Tanzania, the development work in secondary science has been largely aimed at courses in the separate sciences under the school Science Project (SSP), with financial assistance from CEDO. However, in Uganda the interest is in a physics with chemistry course, and in Kenya there is investigation, in the Kenya Institute of Education, of the possibility of producing some bridging topics to link more closely the courses developed separately in each of the sciences. Suggested topics include "energy" and "gases."

In Zambia new work in secondary science—other than the trial of Nuffield materials in the separate sciences in a few schools—is centered on a pilot project for 10 secondary schools in the teaching of agricultural science. These schools were selected because they already had prosperous Young Farmers Clubs and were in close proximity to extension help from the Ministry of Agriculture. The Zambian Association of Science Teachers has also developed an Integrated Science Course for the first two years of secondary education.

The role that science teachers' associations can play in science curriculum development is best illustrated with reference to Ghana and Nigeria. In Ghana, the Ghana Association of Science Teachers (GAST), which was established in 1965, set up an ad hoc committee in 1969 to consider the revision of secondary school syllabuses. This committee became the secondary school group at the Takoradi Workshop held in April 1970 under the auspices of GAST in collaboration with the Ministry of Education and with support from UNESCO. Before the workshop was held the views of members were canvassed on a policy statement concerning the Aims and Objectives of an integrated science course to the stage of the "Ordinary Level" of the General Certificate of Education (the O-Level.) At the workshop itself the group embarked on a specification of the areas of knowledge suitable for an integrated science course extending over five years.

The following main headings were selected:

- The Human Body in Health and Disease
- The Earth's crust
- Weather
- Space Science
- Electrical Phenomena
- Sound
- Heat
- Light
- Energy
- Composition of Matter
- Chemical Change
- Tools, Machines and Engines
- Force and Motion
- Measurement
- Food Production
- Heredity
- Elementary Ecology
- Pressure and Fluids
- Materials and their Composition

These headings were elaborated and regrouped in the form of a syllabus dealing with content knowledge, skills and attitudes. The group also redrafted the policy statement on the aims and objectives of science education at the O—level. Further work is being carried out on the development of this scheme, with supporting materials. The whole exercise, together with similar development at the primary level and at the teacher training college level, now comes under the umbrella of the Project for Science Integration (PSI) in which the Ministry of Education and GAST work closely together, with financial assistance for developing certain aspects of the programme from outside agencies such as UNESCO, CEDO, EDC etc.

In Nigeria, similar vigorous activity of the Science Teachers' Association of Nigeria (STAN) has led to the production of an integrated science course for the junior forms of secondary schools. In this case, however, there are parallel schemes being developed in the separate sciences for the upper forms of the secondary school, also under the auspices of STAN. As long ago as 1966 STAN carried out a survey of science teaching in Nigeria and found that the majority of schools split science up into two or three subjects, though they still called it general science in many cases. A minority of schools tried to present general science as a single integrated subject. The STAN were thus stimulated to look into the approach to teaching science at the junior secondary level and at the same time they were approached by the West African Examinations Council to comment on and to study new approaches to teaching separate sciences at the O–Level. A Curriculum Development Committee was established in 1968 to coordinate these activities.

Whilst these activities were developing, the Ford Foundation had assisted in the setting up of a Comparative Education Study and Adaptation Centre (CESAC) at Lagos University to carry on the work on curriculum renewal and testing being initiated at the Aiyetoro Comprehensive High School. A general science course for the first two years of secondary school had already been developed at Aiyetoro. CESAC showed interest in the work of STAN as also did the British Council and CEDO (formerly CREDO). A new integrated general science syllabus gradually evolved drawing on the experience of the Aiyetoro scheme, the trials of Nuffield materials in the Ibadan area, and on materials developed elsewhere. This syllabus, which was finally agreed at a major seminar held in December 1969, appears in Curriculum Development Newsletter No 1, published by STAN and supported by CEDO through the British Council. The main section headings are:

Exploring Science — Variety in Matter
An Investigation of Air and Water
Forces, Work and Energy
Activities of Living Things
Another look at Energy
Life and Environment

Each section is divided into several units. Altogether there are 16 units to be taught during the two year course.

To elaborate the syllabus in the form of course materials for students and teachers a number of publications are being prepared by commercial publishers. The whole approach emphasises the processes of science and employs the activity or open ended technique with considerable pupil involvement utilizing his environment as far as possible.

SUMMARY OF POSITION AT PRIMARY LEVEL (GRADES 1–5).

	Botswana	Ethiopia	Gambia	Ghana	Kenya	Lesotho	Liberia	Mauritius	Nigeria	Sierra Leone	Somalia	Tanzania	Uganda	Zambia
1. SEPA materials being used.		x		x	x				x	x		x	x	
2. Alternative new science schemes under development		x		x				x	x					
3. Curriculum development centres as co-ordinators.		x		x	x					x				x
4. Teachers' Colleges as centres of activity													x	
5. Health science, rural science or nature study as the normal syllabus.	x		x			x	x				x		x	
6. Integrated primary curriculum under development.												x		x

NOTE: In some countries where there is a nominal syllabus in nature study or rural science little or no science in fact is taught in the first four grades.

SUMMARY OF POSITION AT JUNIOR SECONDARY LEVEL (GRADES 6–8)

	Botswana	Ethiopia	Gambia	Ghana	Kenya	Lesotho	Liberia	Mauritius	Nigeria	Sierra Leone	Somalia	Tanzania	Uganda	Zambia
1. Science taught as traditional general science.	x	x	x			x	x		x	x	x			
2. Science taught as separate subjects					x							x	x	x
3. Integrated science schemes now available	x			x		x		x	x					
4. Science teachers' associations in existence.	x		x	x	x	x		x	x	x		x	x	x
5. Science teachers' associations activity involved in curriculum development	x			x					x	x				

III CURRICULUM PLANNING FOR INTEGRATED SCIENCE TEACHING

(a) The concept of integrated science teaching

Integrated science teaching embraces all the approaches to science teaching (i) in which concepts and principles of science are presented so as to express the fundamental unity of scientific thought, (ii) which emphasize the underlying methodology and processes which characterize the scientific outlook and (iii) which embody a scientific study of the environment and the technological requirements of everyday life. The science courses in the primary and lower secondary schools (to which this Workshop has restricted itself) should be designed to offer the child a broad view of science which enlivens and enlightens his interaction with his environment and contributes to the steady development of his mental, manipulative and social skills. As Professor Babs Fafunwa pointed out in his Keynote Address to the Workshop: "Premature specialization at the primary and secondary levels (and even at the first two years of university work) is a disservice to a nation, in that it is a colossal waste of the limited human and financial resources of a developing country."

There is no single approach to integrated science teaching and many differing courses may be described as integrated. They vary in the "scope", the "intensity" and the "depth" of integration.

"Scope" of integration is the range of subject components included. A course might be designed to include elements of many subject "compartments" or may be of a more specialised kind involving only a few. Both are integrated, the scope of the former being wider than that of the latter.

The "intensity" of the integration is a measure of extent to which the various subject components are integrated one with another. It is possible to devise a course with low intensity of integration in which material drawn from various subject "compartments" is loosely bound together, or a course in which the integration is so intense that subject boundaries are indistinguishable. Both are integrated.

"Depth" of integration is determined by the extent to which the science course is integrated first with the whole school curriculum and secondly with the whole environment in which the school exists. This dimension of integration measures the relevance of the course to the needs of the individual child and the extent to which it furthers the aspirations of the society to which he belongs.

In a fully integrated primary school curriculum, the scope, intensity and depth of integration of the science course would reach optimum levels.

One such curriculum, known as the Karachi-plan curriculum, is based on a "unit plan" organization of subject matter. During a period of several weeks all teaching is centred around a given topic. Thus, for example, the fourth grade programme for the year includes only seven topics, one of which is "Biology in Domestic Space," another "Generating Power and Machines", and so on. The former unit is broken down into sub-units: 1. Man and Environment (physical needs, utilization of nature to this end, public health, personal cleanliness.) 2. The Living Space (house, kitchen, animals in the yard, insect control); 3. The Cultivated Field (vegetable, potato, flour plants); 4. Uncultivated Nature (rivers, the sea) 5. Man himself (how the body functions, first aid).

This represents an attempt to fully integrate the curriculum. A Tanzanian Pilot Project is attempting curriculum integration in a similar way, but further integrating the school and society by choosing "centres of interest" which are the developmental needs of the village to which the school belongs.

ERIC

In curricula of these kinds applied science and technology are given a stronger bias: the belief is that rural development in particular must have a sound basis in agro-technical expertise and knowledge of scientific principles.

It is not suggested that the fully integrated curriculum is the only way in which rural development may be promoted. Indeed, many other examples exist in which there are science and agriculture components, included specifically for that purpose: some of these are successful, others have failed miserably. It is possible to say, however, that rural development is heavily dependent on science, and where the integration of the school science is wide in scope, strong in intensity and profound in depth, there appears to be a greater likelihood of its contributing significantly to the development of rural communities.

It is important to note here that while science education has a major contribution to make in the process of seeking and acquiring knowledge about the world around us, and also, if appropriately taught, can make a considerable input in areas such as skills of living, communicating and adapting to change, the teaching of science alone cannot make a major contribution to decision making. As was pointed out at the Nairobi Seminar on "Education for Rural Development in Africa", the scientist may address himself to problems such as "what is the effect of this particular fertilizer on plant growth?" and answer them by following proper research techniques in which opinions and views have no part; he cannot claim an exclusive role in answering a question of the type "Should I put this fertilizer on my crops this year?" The answer to this question will be affected by factors which are non-scientific, as well as drawing on the knowledge gained through scientific enquiry. It is nonetheless the responsibility of science educators to encourage the communication of scientific information, thus facilitating this type of decision making.

Planners of all kinds should be aware of this limitation upon the responsibility placed on science in development programmes, and education planners in particular might like to consider how training in decision-making might be included in the curriculum.

Another kind of limitation is sometimes imposed on science teaching by curriculum planners themselves. This has nothing to do with the nature of science itself, but is of such common occurrence that it warrants mention here although it will receive further treatment when we come to consider a curriculum model in subsequent pages. If the science taught in the school is restricted to the "manifestations" of science, i.e. the technology and the applications, and is not firmly based on the "process" of scientific enquiry, then the impact of such science on long-term development will be restricted, even though it may be integrated and possessing scope, intensity and depth to considerable degrees.

The need to devise courses covering the whole range of the sciences in a balanced way was widely felt some 40 years ago. The teaching strategy then devised was to develop "general science" courses. Such courses were co-ordinated surveys of physics, chemistry and biology. Only rarely was there real unity in the presentation of the course. In some cases an attempt at unity was made through a "topic" approach. With some notable exceptions the teachers failed to achieve any real integration in their teaching, partly due to lack of real guidance in how to do this. Rarely did teacher training courses prepare teachers for a unified approach to their teaching.

Two advances in other areas provided the key to the production of science courses that are, in fact, integrated. In the first place it became clear that the major advances in scientific research are taking place in interdisciplinary areas—molecular biology, geophysics, biochemistry and astrophysics, to name a few. Such advances were often the results of

methods and techniques developed in one scientific field being applied to the subject matter of another. This emphasized the totality of science, the fact that the boundaries which had formerly been taken for granted were becoming blurred and illusory.

The second breakthrough came in science education itself when the first large scale curriculum projects developed new courses in physics, chemistry and biology, and later in earth and space science. Physics was no longer a mixture of light, sound, dynamics, hydrostatics, electricity and magnetism. Physics itself became unified. The major concepts were identified. School children were introduced to the idea of building models to explain phenomena on the basis of existing knowledge. It could no longer be said that chemistry and biology were primarily concerned with encyclopaedic masses of facts. In each of these disciplines some major principles were developed as threats with which to weave a fabric that highlighted the methods and processes actually used by investigators in these fields.

Integrated science teaching thus represents the next logical step in the evolution of science courses. As indicated by Chief Awokoya in his opening address, the need was felt to think about "science as a whole as it affects the child in the totality of his environment." There is a variety in the methods of achieving integration, but each course in its own way draws on the insights outlined above which were acquired during the last decade of curriculum development. Science teachers are becoming aware that they should concern themselves, above all, with the development of desirable attitudes to the natural world and to man's interaction with it. Some workers have identified the basic, fundamental concepts that can make science meaningful in a rapidly changing world. In such a course the teacher does not set out to "teach a concept" Rather, he provides activities that give the children opportunities to develop concepts. Other science educators have argued that it is the processes of science that make it so important in our modern world. They put stress on giving children opportunities to observe, measure, classify, interpret data etc.—in fact, all the processes outlined in Professor Fafunwa's Keynote Address. There are also programmes which emphasise the applications of science. In almost all courses, the child's own environment is used as the starting point for the course and as the focus of much of the activity.

Most of the recent integrated courses involve all those aspects. One of the schemes extends the concepts and processes to the search for patterns. It is felt that this will lead to a better comprehension of science, that children appreciate the gradual appearance of structure and order. In this programme the content is organized round three basic ideas, each one representing integration in itself—building blocks, interaction and energy. Another course that also builds on both concepts and processes leads to model building.

At the lower primary level, science teaching is inevitably integrated, the scope and intensity of the integration determined wholly by the child's interests and interaction with his environment. At upper primary and lower secondary stages, however, when the child's ability to abstract and conceptualise is developing, there arise questions of "approach" to science teaching. The approaches are sometimes classified as "enquiry", "conceptual", "relevance" and "process" with an "eclectic" approach drawing upon elements of all of them. They may all, to greater or lesser degrees, be integrated in scope and depth, the intensity of integration varying considerably. Is there justification for integrated science teaching at these levels on philosophical, psychological, pedagogical and practical grounds?

Traditionally, the approach to science and related problems has been analytical: this has been formalised in the traditional subject syllabus. Pre-occupation with analysis has blinded us to the vital role of synthesis and has contributed in large measure to the irrelevance of

much that has been included in school syllabi. Deeper understanding of our world presupposes involvement in both processes, and integrated science teaching is felt to be a suitable vehicle for them. On philosophical grounds, therefore, it is believed that an integrated approach to science teaching promotes the building of a more balanced world picture.

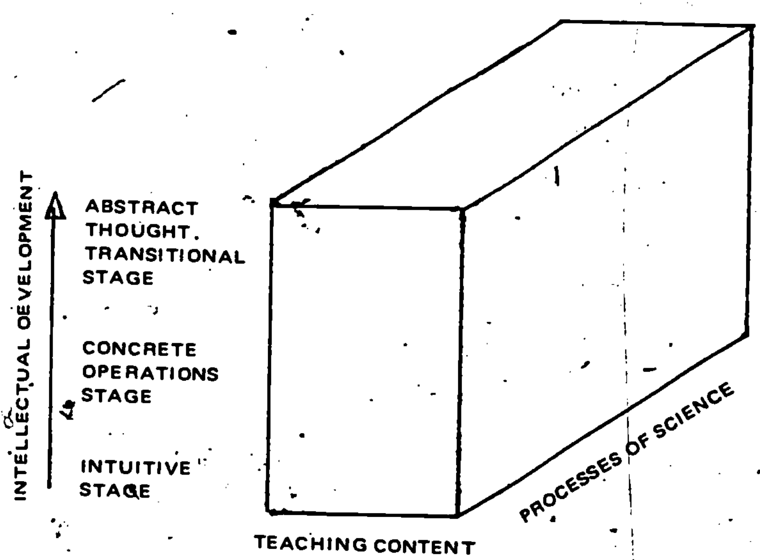
There are also good psychological grounds, if it is accepted that the child's ability to abstract is developing rapidly in later primary and early secondary years. There should be no inhibiting of his freedom to experiment with concepts and groups of concepts: such restrictions stunt the development of intellectual and manual skills. An integrated science teaching approach is believed to encourage this freedom.

On pedagogical grounds, the inclusion is justified in that it provides a teaching environment which stimulates "professional growth" in teachers. The teacher, by the very nature of his work, is pursuing knowledge with his pupils. His important role in easing the transition from concrete to abstract is underlined: it gives teaching a new dimension and a flexible framework in which to flourish. The materials used under these conditions are of greater relevance and interest. At the "frontiers of knowledge", the approach is increasingly interdisciplinary and the school situation should reflect this.

Practical considerations are that much duplication of effort and resources can be avoided and that it may be possible to relieve time-table pressures to some extent.

On the basis of these considerations, therefore, it is possible to proceed to a discussion of the ways and means whereby a curriculum planner could introduce an integrated science component into the curriculum, using a model which would be adaptable to the circumstances of any particular school, society or nation. It is emphasized that curriculum planning which does not pay due regard to political, economic and cultural factors within the society for which the curriculum is designed is an academic exercise only. The model shown in the figure is designed to identify possible common ground and to demonstrate degrees of freedom within the curriculum planning process. It is by no means the only possible model and it is unlikely that all planners would agree that a curriculum model should necessarily be three dimensional.

A Guide for Curriculim Planning for Integrated Science Programmes



The three dimensions chosen here represent the three major factors thought to be of concern to curriculum planners:-

1. Processes of science
2. The child's intellectual development
3. Teaching content

1. Various analyses of the basic scientific processes have been made, notably that presented as a basis for the American Association for the Advancement of Science "Science a Process Approach" programme.
   Professor Babs Fafunwa listed fifteen behavioural objectives derived from this programme in his key note address.*
2. The work of Piaget and other educational psychologists provides a basis for a vertical axis scale on the diagram and gives some indication of the child's limitations and potentials at three stages. It would be unfortunate if these stages were thought to be clearly defined: there is a merging and overlap which it is not possible to depict on the diagram.
3. The "content zones" chosen for representation on the third axis are thought to comprise the "total environment" which provides the centres of interest for integrated science teaching. Each zone is deliberately wide in scope, and inevitably there is some overlap, but it is desirable to work with a small number of zones. Content may be based on:
   (i) the cultural environment
   (ii) biology
   (iii) chemistry
   (iv) physics
   (v) other sciences e.g. earth and space science
   (vi) technology
   (vii) aspects of social science

   Many topics introduced as suitable teaching materials will offer opportunities for different types of investigations. For example, "wood" will introduce biology-based content (trees, growth, natural function), chemistry-based (composition etc.), physics (strength of materials, etc.), technology (building etc.).

As an example of the problems that face a curriculum planner in integrated science teaching, a mythical African country is considered as a theoretical model. The more proximate goals of this country's government are expressed the First Ten Year Development Plan which provides for expansion of the social services, improvement of communications, modernization of agriculture and the introduction of free and universal primary education. The Ministry of National Education in responsible for primary and secondary systems throughout the country and has translated the national aspirations into terms of the following educational objectives:

1. To promote the development of functional literacy and numeracy.
2. To promote the development of an understanding of the country and its culture, enabling it to conserve desirable elements of its culture and transform others.
3. To promote the rapid development of traditional manual skills in the light of modern technology.
4. To promote the development of social skills.

* see Annex V

Some fundamentals of the country's education programme

1. The primary education system accommodates 25% of the children of appropriate population group; the secondary education system 5%
2. There is a high drop-out rate in both primary and secondary sections, estimated at 40% in the former and 30% in the latter.
3. Fees are paid at all levels.
4. Pupil/teacher ratio is 50/1 at primary and 40/1 at secondary levels.
5. The secondary education system absorbs less than 1 in 5 of primary school leavers.'
6. The primary leaving examination dominates the curriculum of the primary school while the External Examination Council syllabuses dictate secondary syllabuses. There is no intermediate examination between grades 6 and 10.
7. The teaching style at both levels is traditional, formal and heavily subject–orientated.
8. School buildings are generally rudimentary, designed mainly according to the "train" plan with self-contained classrooms.
9. Science teaching areas in schools are often inadequate.
10. 50% of primary school teachers are untrained: the remainder have had two years' teacher education, with no specialist science content.
11. In secondary schools, 20% of the teachers are qualified graduates, 20% ex-patriate staff, 40% non-graduate, 3 year trained local staff, 20% unqualified staff.
12. The objectives of the country in integrated science teaching are stated as follows:

"Through science-based experiences, to promote the acquisition of functional knowledge, attitudes and skills associated with the improvement of agriculture, health and nutrition and to enable children leaving school to apply these to the improvement of life in their environment."

Primary School Level

Human Resources

A study of the country's education system revealed training needs on the part of the teachers at the primary level. Therefore, both pre-and in-service training programmes were initiated. The pre-service training was done through the teacher training colleges. The science tutors of these colleges were the first to be orientated by those concerned with development of the new curriculum. This orientation involved encouraging the participation of the tutors in the actual process of developing new teaching materials. In-service courses (workshops) for practising teachers were also arranged at centres up and down the country. All these courses were of a practical type, with the teachers themselves actively carrying out the practical work. Some teachers were also involved in the actual production of teaching materials.

Material Resources

The new teaching materials produced were mainly teacher's guides and some science readers for the children. These materials, as noted above, were prepared by practising teachers and science educators. The writing group first decided what topics were to be covered, on the basis of what they thought were of interest to children and suited to their particular stage of intellectual development. They then went to actual live classes with the materials necessary to teach the topics. These materials were then presented to the children who were encouraged to interact with them, while members of the writing group observed what went on in the class. The ways the children interacted with the materials then suggested the approaches to be adopted in providing learning experiences for the particular topics.

Unsatisfactory materials were modified, and topics that were not of interest to the child-

ren were abandoned. Thus, materials produced derived from observed interests and interactions of children. This ensured that selection of topics and learning experiences was learner-screened. This meant that the learning experiences were appropriate to the group of children. None the less the materials were also tried out in other places, after prior workshops for participating teachers.

Other pieces of material and equipment derived almost entirely from the school and community. Therefore, there was no problem of a financial barrier to the implementation of the programme. Further, the type of teacher-pupil interactions demanded by the new programme only involved a re-arrangement of benches and desks to facilitate group work, interchange of ideas and free movement among the children. Thus the physically passive learning environment of the traditional self-contained classroom was transformed into an 'action learning environment' where the children learned by doing. It was also necessary for the teachers to provide all the materials required for exploration and learning. And because the materials were derived from the environment, this implied an integration of the school with the community.

Implementation

In the new science programme, there was a change in the teacher's role which became supportive rather than prescriptive. The classroom climate was democratic, the support system (equipment, materials etc) became extensive and responsive, and the teacher indeed a stimulator, a resource and fellow participant facilitating children learning. A typical lesson of this programme would show children interacting with materials and one another, working either individually or in small groups, so that much of the children's learning was self-directed, the ultimate goal being to promote autonomous learners who would be able to carry on their own exploration and learning with a minimum of direction. In other words, the children were being trained to take responsibility for their own learning.

Evaluation

If the instructional objectives are the behaviours we want the children to acquire from the learning opportunities provided, we may wish, ideally, to determine how much of the behaviours have been actually acquired at the end of the lesson. This measurement of change (if any) is evaluation. The process is made simple by our identifying and specifying the changes prior to the learning experience. Evaluation provides the learner information about his progress, as well as the teacher who might provide remedial experiences if need be.

A WORLD PICTURE

The diagram below was an attempt to represent the environment schematically and in a manner likely to encourage the selection of themes and topics for use in integrated science courses. It may be noted that many interrelationships are not shown, yet those which are present tend to encourage recognition of the similarities which exist in all living matter. Man, basically an animal, centrally a "thinker-doer" is enveloped by his own technology by which he most comonly interacts with his environment. Might this type of world picture be of the kind which one might hope the child would develop through his science education?

Junior Secondary School Level

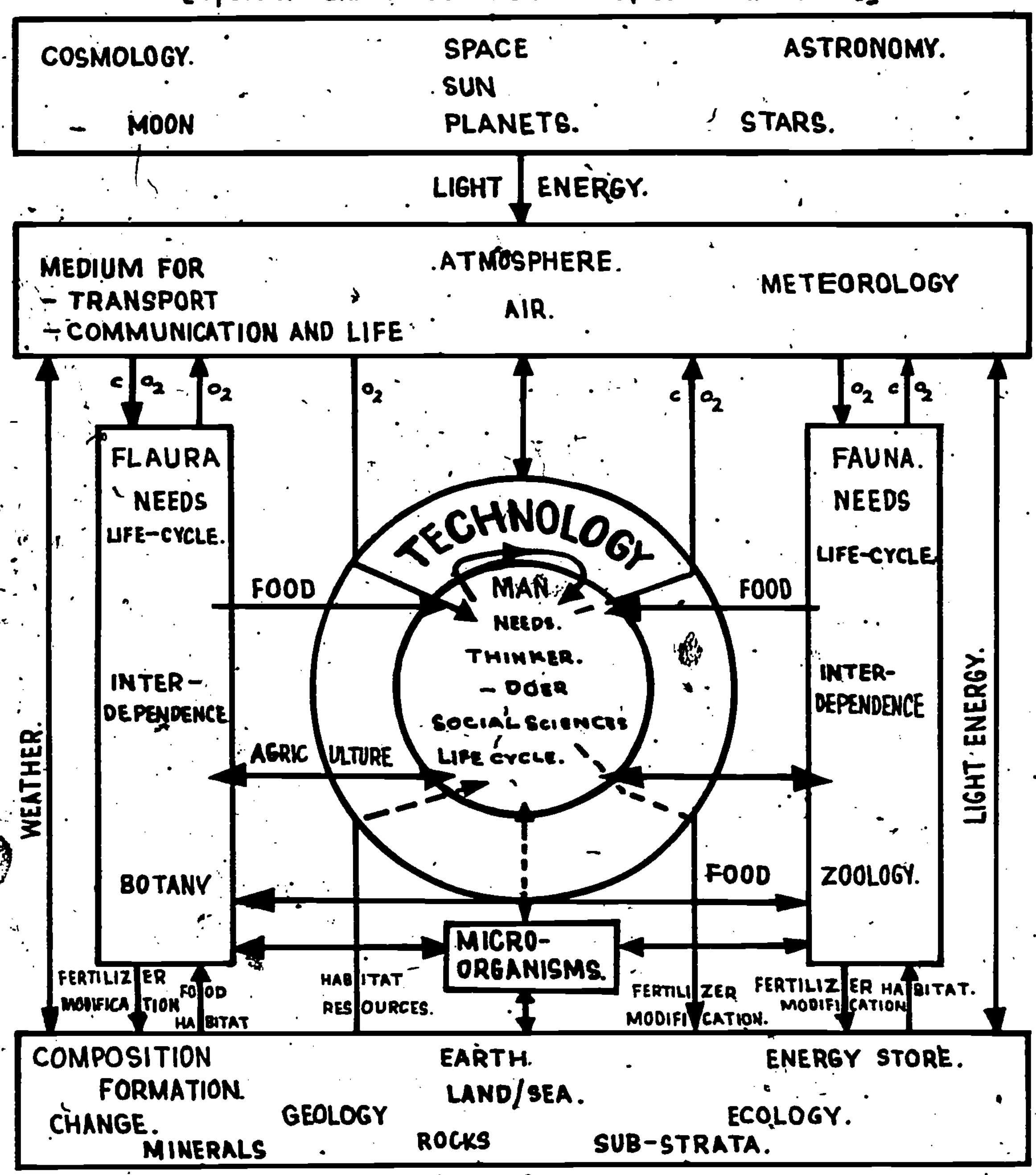
Many of the problems with regard to human resources, material resources, and curriculum implementation and evaluation were comparable to those at the primary school level. An extensive programme of curriculum development and teacher re-training was embarked upon. A two-year integrated science teaching programme was drawn up which continued the topic-based approach from the primary school, but which placed an increasing emphasis on concept-based teaching materials as the pupils progressed.

The following content areas were selected for the two-year programme:

1. Our Food
   - Types
   - Origins
   - Production
   - Preparation
   - Benefits of Food
2. Food for other organisms
   - Plants
   - Animals (insects, birds, fish, etc.)
   - Micro-organisms
3. Our Senses
   - Sight
   - Hearing
   - Touch
   - Taste/Smell
   - Kinaesthetic

A WORLD PICTURE

[A possible aid for Selection of topics and themes]



4. The Weather
   - Wind
   - Rain
   - Sunlight and Heat
   - The Effects of Weather
5. Shelter
   - Materials
   - Tools
6. Forces
   - Pushes & Pulls
   - Magnifying forces
   - Using forces
7. Movement
   - Mechanical movement
   - Movement in nature
8. Energy
   - Our Energy
   - Other sources of Energy
   - Using Energy
9. Man—A Machine
   - Function of parts
   - Growth
   - Regeneration
   - Reproduction
10. Building Blocks
   - Are all things divisible?
   - Building more completed things

As is so often the case, the content headings and sub-headings given above reveal little of what was intended in terms of classroom activities. Throughout the programme it was intended that the student should exploit the materials found in his environment in the process of enriching his insights into his physical environment and expanding his personal world picture. The area 1.—Our Food, for example, provides opportunities for collection, observation and classification of foodstuffs. These processes may range from those based on superficial examination to those dependent on investigations leading to an understanding of the types of foodstuffs required for a balanced diet. Aspects of Nutrition and Agricultural Practice may be associated with the work.

Area 8—Energy, proposed for a later stage in the programme, is concept based, and whilst starting homocentrically, develops to encompass exploitation of energy sources, natural and contrived, which are parts of the pupil's environment. Area 9 Man—A Machine offers the context for further work on hygiene and the introduction of basic sex education. Here one might expect midwives to be used as resource personnel and visits to ante-natal clinics to feature amongst the activities undertaken.

It will be noted that while ten topics have been identified for use in the two year programme, no time allocations were given. This absence of allocations represents a degree of freedom offered to the teachers. Different groups of children with their teachers will find different topics of particular interest. While this interest is sustained and accompanied by new insights and productive activity the work should continue. Thus each class will "personalize" its own science programme and yet experience a defined range of materials and learning experiences designed to implement the stated behavioural objectives of the course.

In the description of a lesson which follows, it will be noted that many different activities might have taken place. The description is in outline only, so as to permit the reader to reflect on the opportunities for creative thinking offered by the classroom situation recounted.

(C) An Integrated Science Lesson

Background: The lesson described is one of a series on the topic "Shelter—Materials" taking

place towards the end of the first year of secondary education. The class consists of 40 boys and girls (ca. 12 yrs.) and the lessons take place in an ordinary classroom furnished with wooden desks and chairs. The teacher, a qualified non-graduate, has a few years experience but no pre-service training in the techniques of integrated science teaching. He has attended an in-service course on the programme being taught and is supported by a printed resources book which provides both a discussion of the philosophy of the course and a detailed discussion of the topics and their development, and includes suggestions for starting points and exploitation of local materials.

The class has previously undertaken a survey of the types of shelters found in their town/village and school—from storage shed to hospital. Each type of shelter has been discussed, its functions analysed and its shortcomings identified. It has emerged that different shelters are composed of different materials, and the class is to continue its work by investigating these materials.

Lesson Objectives

1. To observe and report precisely and objectively.
2. To categorize materials by function; e.g. roofing materials, wall materials, window materials, etc.
3. To design and use experiments leading to a better understanding of the physical properties of building materials.
4. To develop an understanding of the problems solved when building a shelter.
5. To exploit their command of English (medium of instruction) as a means of sharing experiences and insights with others.

A variety of samples of building materials have been assembled in the classroom. The student's notebooks contain descriptions of local shelters examined in earlier lessons together with sketches and notes on construction.

The teacher invites the class to suggest means by which the materials collected may be grouped. Once the problem has been posed he drops his dominant role adopting a role as consultant. A few minutes of class discussion follow, as a result of which proposals to group materials under the following categories emerge—(a) local materials, imported materials; (b) plant materials, metal, stone, mud, etc.; (c) wall materials, roof materials, etc. These groupings are discussed and interest is shown in plant materials, wall materials and roof materials. The class is then encouraged to undertake further work, examining these materials in order to learn more of their properties. The teacher wishes to stimulate investigation of the following questions:

Pland materials—are all plant materials useable?
—what parts of plants are most often used?
—what physical properties have these materials?
e.g. strength, waterproof nature, long life, etc.

Roof materials—what properties must roof materials have?
—how well do the materials examined match the ideal requirements?
—are all equally good for all roofs?

Wall materials —what physical properties do the materials available have in common?
—are all equally suitable as wall materials?
—how are local materials prepared?

These questions are not asked directly of the groups of children who have now clustered around each of the three categories of material. Initially student activity is limited to discussion and superficial examination/handling of "familiar" materials. The Plant materials group become

interested in the different types of wood—one type being identified as being "termite-proof"; they are encouraged to find out if all the various woods present are equally strong—a range of experiments are undertaken; some crude, others based on a more thoughtful, sophisticated approach. The Roof materials group think that rain-proofing and shelter from the light and heat of the sun are the most important properties of roofs and are encouraged to check which material provides best protection from the sun—they move outside the classroom to start their work. The Wall materials group have identified the need for walls to be either unaffected by water, or protected from it—an experiment to find the effect of standing a piece of mud brick in water is initiated by the group itself.

As has been the case throughout the year, students are encouraged to make notes of "significant findings" in their science books. Full sentences and correct use of language is encouraged.

The lesson draws to a close as the various groups are asked to show each other the activities which have been undertaken—discussion and suggestions for further investigations emerge, the teacher noting them on the chalk board. The teacher retains his role as consultant throughout this interchange of experiences whilst stimulating a critical approach to information supplied and conclusions drawn. Before the end of the lesson the groups select from the proposed future activities those which interest them and seem likely to add more information and insights to those already gained about the materials and their properties. The Plant materials group want to find out whether plywood is stronger than bulk timber. (They have selected a difficult topic and will need help here). (The Roof materials group want to know why galvanised sheet is corrugated. The Wall materials group want to know how strong various materials are when "squashed" (i.e. under compression.)

These topics are noted by the teacher who will arrange for "useful items" to be available for use in the classroom during the next lesson—a resource for the pupils in the development of experiments and tests. (Here the teacher is greatly supported by his resource book which suggests means by which the strength of materials may be tested when under compression and in shear—local materials are indicated which may be incorporated in test rigs devised by the children.)

The lesson described above took place in the absence of a laboratory, without electricity, sinks and taps, or a gas supply. The teacher, as yet unskilled in the techniques of this style of teaching, found considerable support in his teacher resource book, not only in terms of background information but also as related to the approach to be adopted and the patterns of activity to be encouraged. He had previously been made aware of the various roles he might adopt in the classroom by the experiences and discussions associated with his in-service training. He still "leads" the class rather strongly, yet they already have the freedom to adopt their approach to the environment rather than being completely restrained by the teacher's dictates and pre-dispositions. The classrom was "enlarged" by the use of the school yard for one of the group's experiments and by the recent visits to local shelters—homes, stores, etc. The work in science has thus been tied to the life of the community and the pupils' homes.

Whilst, as yet, there is no great emphasis on the principles of science, concepts and conceptual structures, processes and skills are actively being utilised and developed. Most important, the students are establishing a history of experiences in which they interacted with their environment in a productive fashion, gained insights which relate well to everyday life, and are learning that "success" and "failure" are relative terms rather than absolutes—reflecting the usefulness of their achievements when viewed in terms of their own objectives.

IV SCIENCE TEACHING MATERIALS, EQUIPMENT AND FACILITIES

Introduction

The basic premise is that instructional materials, aids, equipment, and the physical structures should be designed and developed to serve the general purpose of education within the framework set out in PART III of this report. As expressed in Part III, the ultimate aim of education remains relatively unchanged, but the operational objectives which serve as a process of attaining it need to change because environmental conditions have not remained static. There is also a recognition of the fact that integrated science teaching is related to all phases of a person's life including the biological, physical and cultural aspects of his immediate environment. To illustrate: an investigatory look at an object or group of objects from the environment (e.g. a stone, wood, a calabash, or any object of interest) may lead to explorations that relate to the chemical, historical, distributional, biological, and mathematical aspects as well as to artistic, cultural, and linguistic significance and attributes. The suggestions that follow are based on this premise.

Audio-Visual Aids

Within the framework of integrated science teaching, activities that take place in learning situations are centred around **concrete objects** (instructional materials) which help to trigger curiosity. The selection of such materials might be unstructured, as it is at the primary level, or guided by an awareness of an organizing theme on the part of the teacher. In the main, however, the selection of appropriate materials depends largely on the teacher's use of his/her ingenuity and flexibility, and upon the demand of the situation as he or she perceives it. General considerations would include the following:

(i) the materials should be selected from the students' immediate environment;
(ii) they should capture and hold the students' interest;
(iii) they should be rich in potentialities for inquiry activities.

The three points are illustrated in the case of a teacher who happened to bring into her science room a charcoal cooker made in the local village. Its presence in the science laboratory sroused the pupils' curiosity and generated a great deal of inquiry activities and investigations into its scientific uses. The teacher allowed the students to utilize the occasion to engage in meaningful activities that had educational significance.

Highly developed technical and electrical devices such as television require proper maintenance and repair facilities. Teacher education in the best use of such facilities is also necessary.

Film projectors, slide and film strip projectors and other aids are not useful in their own right, but only in conjunction with the requirements of the learning situation and the physical facilities available. For example the slide projector is useful only when the following have all been met:

(i) the slides to be shown are relevant to the learning situation;
(ii) the slides can be clearly seen in the environment in which they are to be shown;
(iii) the power for the light source is reliable;
(iv) spare parts are available;
(v) the teacher can use the equipment;
(vi) the supply of slides is available when needed;
(vii) adequate foreign exchange is available for the importation of the audio-visual materials.

ERIC

Science teaching Materials and Equipment.

For integrated science teaching to be effective at the primary and lower secondary levels the teacher's resourcefulness in the development of materials and equipment must be supplemented with the physical ability to put his requirements into practice. To achieve this, the following local and national assistance is desirable:

1. Teachers' Centres

Materials and Equipment development would be greatly enhanced by the establishment of teachers' centres. Such centres provide facilities where teachers can construct equipment and apparatus, develop instructional materials and share common experiences and ideas. There would be trained laboratory personnel staffing the centre, either full or part time, who would assist teachers in basic techniques of construction. A teachers' centre cannot function effectively without a flexible administrative set-up that facilitates expeditions procurement and utilization of basic materials and needed funds.

2. A National Curriculum Development Centre.

The above-mentioned comments on teachers' centres in no way preclude the existence of a national centre for curriculum development; in fact teachers' centres can hardly function effectively without the National Centre. The National Centre is not viewed narrowly but more broadly to include an equipment production section, which would be part of the general curriculum renewal effort. Thus the National Centre would cut across Ministry boundaries to be linked with the Ministries of Development, Works, Economic Planning, and others as appropriate, as well as with the Ministry of Education. In countries comprised of large states or provinces, or regions, it would probably be desirable to have such centres at state levels also.

3. Printed Materials

Limiting consideration to the primary and lower secondary levels, there is a need to involve the national curriculum development centre as a facilitator in the development and production of printed materials within the contexts described below.

(i) In the ideal situation a teacher would prepare written materials within his or her own school in collaboration with his or her colleagues across the curriculum subjects.

(ii) In cases where teachers cannot handle this task, Workshops would be organized. The purposes of these Workshops would be to familiarize teachers with integrated science teaching and to give them guidance in preparing written and illustrated instructional materials for themselves. The Workshops could involve teachers of one school only or teachers from a few schools, or selected teachers from various parts of the country. The written materials would be used on a trial basis and would continue to be improved.

(iii) For practical purposes at this time, some illustrative teachers guides could be prepared and teachers would be invited initially to draw upon them to suit their own situations. Subsequently, teachers would move progressively to a point where they could prepare their own guides. The national curriculum development centre and international education development agencies would cooperate not only to facilitate the availability of illustrative teachers' guides, but also to serve as a continual motivating factor in helping teachers perceive their expanded roles and competencies.

(iv) In the case of the lower forms of the secondary school, the teachers' efforts would largely follow guidelines on curriculum items prepared by the appropriate authority. In the case of the primary school, however, there would be no such guidelines and the starting point would be concrete objects which have captured and aroused the pupils' interests.

ERIC

There is no apparent need for prescribing a **students' textbook** at either the primary or lower secondary levels. By textbook in this context is meant a required class book which is used by all students, at the same time, for the same purpose under the teacher's supervision. Instead of a textbook there should be a **Resources Centre in the school** containing all kinds of materials suitable for use by students and by teachers. Included in the Resources Centre would be teachers' guides, students books, reference material, charts, books on local plants, animals, customs, etc. The Centre would be easily accessible to both students and teachers.

In both primary and secondary classes there would be **no workbooks for students.** Workbooks as they exist to-day are too structured and discourage creative investigations on the part of students. A more flexible approach would suggest that the Resources Centre should also contain loose paper of all kinds: ruled sheets, unruled sheets, tracing paper, drawing paper, graph paper, etc. as well as chalk and crayons of various types. Pupils would utilize these materials as the need arose.

4. Equipment Production

At the primary and lower secondary level equipment construction is child-centred and, as previously expressed, depends upon the teacher's resourcefulness as much as does the development of printed materials. Financial aid should be directed towards providing basic construction equipment such as hand tools and raw materials rather than finished goods. Advice and expertise should be available from the National Centre and local Teachers' Centres. Local expertise such as that of other professionals, carpenters and other craftsmen should be used as the occasion demands, e.g. to produce items including those shown in the sketches.

The emphasis on production of appropriate printed materials and equipment implies that the Government of a country needs to direct external aid towards the development of local industry.

5. School Buildings

New Facilities

The establishment of new facilities assumes a number of basic considerations for the development of prototype buildings for primary and lower secondary classes:-

(i) **Site**

The entire site should be developed as an educational environment.

(ii) **Integrated Curriculum**

The area should be developed within the context of integration of the entire curriculum; but for the purposes of this document only the integrated science area is developed and links to other subjects merely indicated.

(iii) **Outdoor Teaching.**

The building should cater for outdoor extension of learning activities.

(iv) **Extra - Curricular Activities.**

Provision needs to be made for extra-curricular activities such as science clubs, community health and nutrition programmes, general agriculture, etc.

(v) **Open Plan.**

It should be as 'open' as possible even if that implies absence of walls; but there should be lockable facilities for storage, and protected space for continuing projects.

(vi) **Central Resources and Workshop**

There should be a centrally located resources area and workshop which would be easily accessible to teachers and pupils.

(vii) **Use of Structure for Aids**
The structure should be such that the use of aids can easily be facilitated e.g. by ceiling attachments.

(viii) **Animal Area.**
An area in which to keep animals should be provided and it should be observable from inside and outside the integrated science area.

(ix) **Demonstration and Production Gardens.**
The integrated science area should be related physically to demonstration gardens and plots suitable for large-scale production of crops.

(x) **Student Groupings**
The teacher-student ratio in the example given is 1:40. The entire area should be suitable for students working in pairs or in groups of 8 to 10 in number.

(xi) **Resource Materials.**
Resource materials should be supplied to cater for immediate use in continuing project work i.e. books, tools and basic raw materials.

(xii) **Student Project Storage**
The provision of secure storage space for continuing project work must be supplied for students to ensure continuity.

(xiii) **Large-Scale Demonstration Aids Outdoors.**
The provision of such aids should be made to allow for meaningful 'play-group' activities, at beginning levels.

(xiv) **Unstructured Discovery Area.**
In conjunction with outdoor demonstration aids, an unstructured area should be provided for an individual to develop his own activities.

(xv) **Portable Teaching Equipment.**
The equipment provided should be of a portable, mobile nature, e.g. apparatus trolleys, movable low-partitioning; chalkboards, storage bins, etc., so that the teacher can effectively use the equipment as the occasion demands.

(xvi) **Community Use of School**
The facilities of the school should be such that the school can effectively serve as a "community centre" in the realms of mass communication.

(xvii) **Deck and Stage Area**
The irregular structure of the deck and stage area offers teachers working within the integrated school curriculum possibilities for many varied activities.

Existing Facilities.

To move towards a suitable environment for integrated science teaching it is possible to analyse and alter existing structures and 'open-up' the teaching area. The approach necessary embodies:-

(i) Examination of the existing facilities and timetable to seek areas of more effective utilization.

(ii) Modification of existing buildings to increase this effective utilization: for example, convert 3 general classrooms for use in integrated science teaching (3x600 = 1800 sq. feet); increase the utilization within the 3 science spaces from an average of 60% in most existing

cases to 80%. The above would give two new integrated science rooms plus one specialised science room without adding new space.

(iii) Expansion of 'waste areas' in the vicinity of integrated science rooms.

(iv) Effective teacher training to re-orientate the teachers towards developing fully the potentials available to him.

Recommendations.

(1) The Establishment of a National Curriculum Development Centre which includes facilities for the development and production of equipment and printed materials for trial purposes.

(2) The encouragement of the establishment of local teachers' centres for local development and construction of teaching materials and equipment, in conjunction with the National Centre.

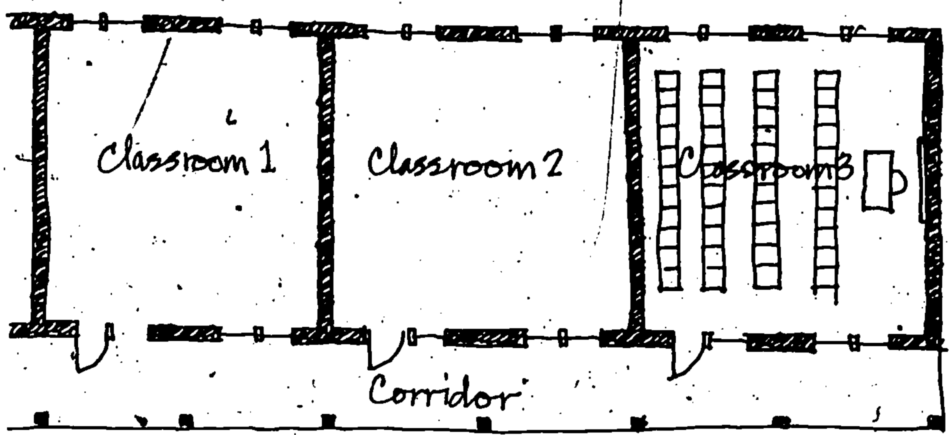
(3) The development of school buildings to enable the integrated science learning situation to be effective. A suitable building could be based on the design shown.

(4) An evaluation of the effectiveness of highly developed visual aid equipment in terms of the ancillary facilities available for its effective supplementary use in the integrated science approach.

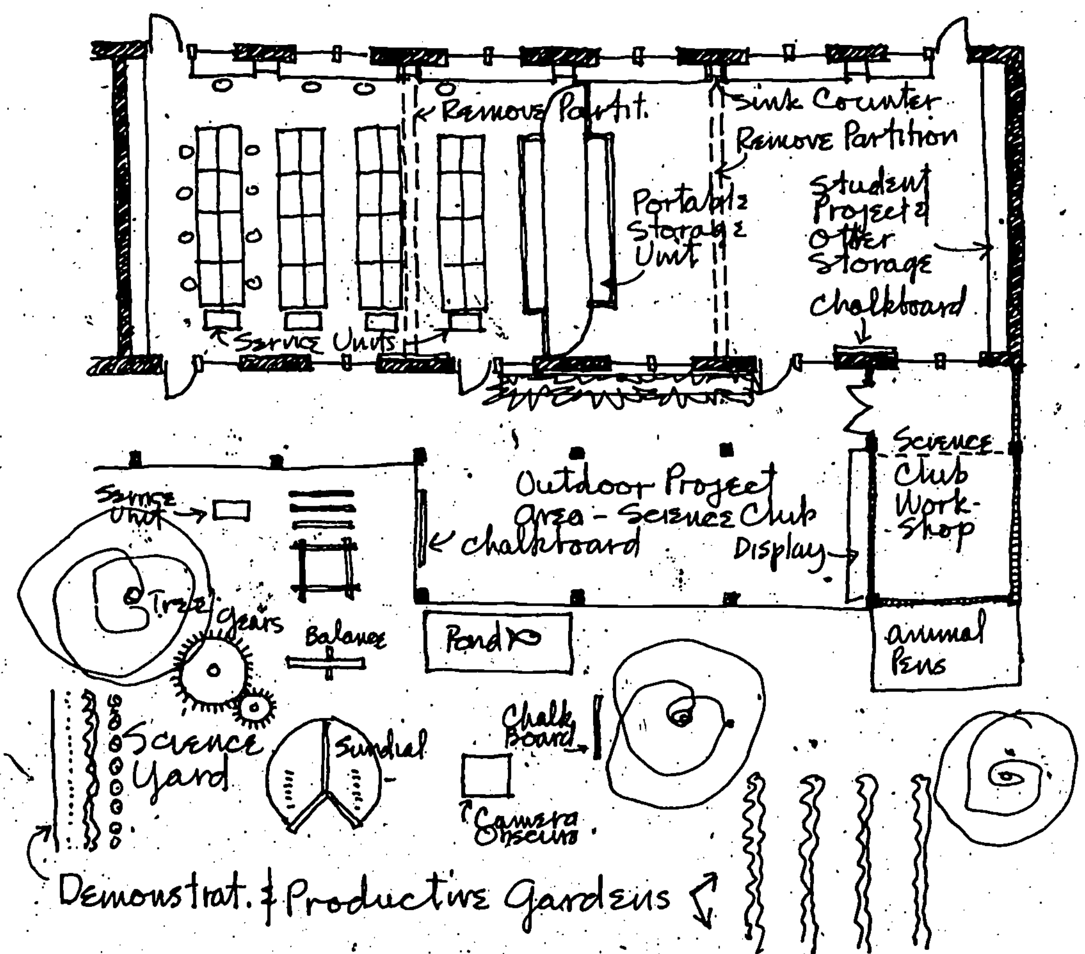
(5) That teacher training courses include basic training in handicraft techniques.

(6) International and bi-lateral aid agencies should be approached to assist in the establishment and implementation of the above recommendations.

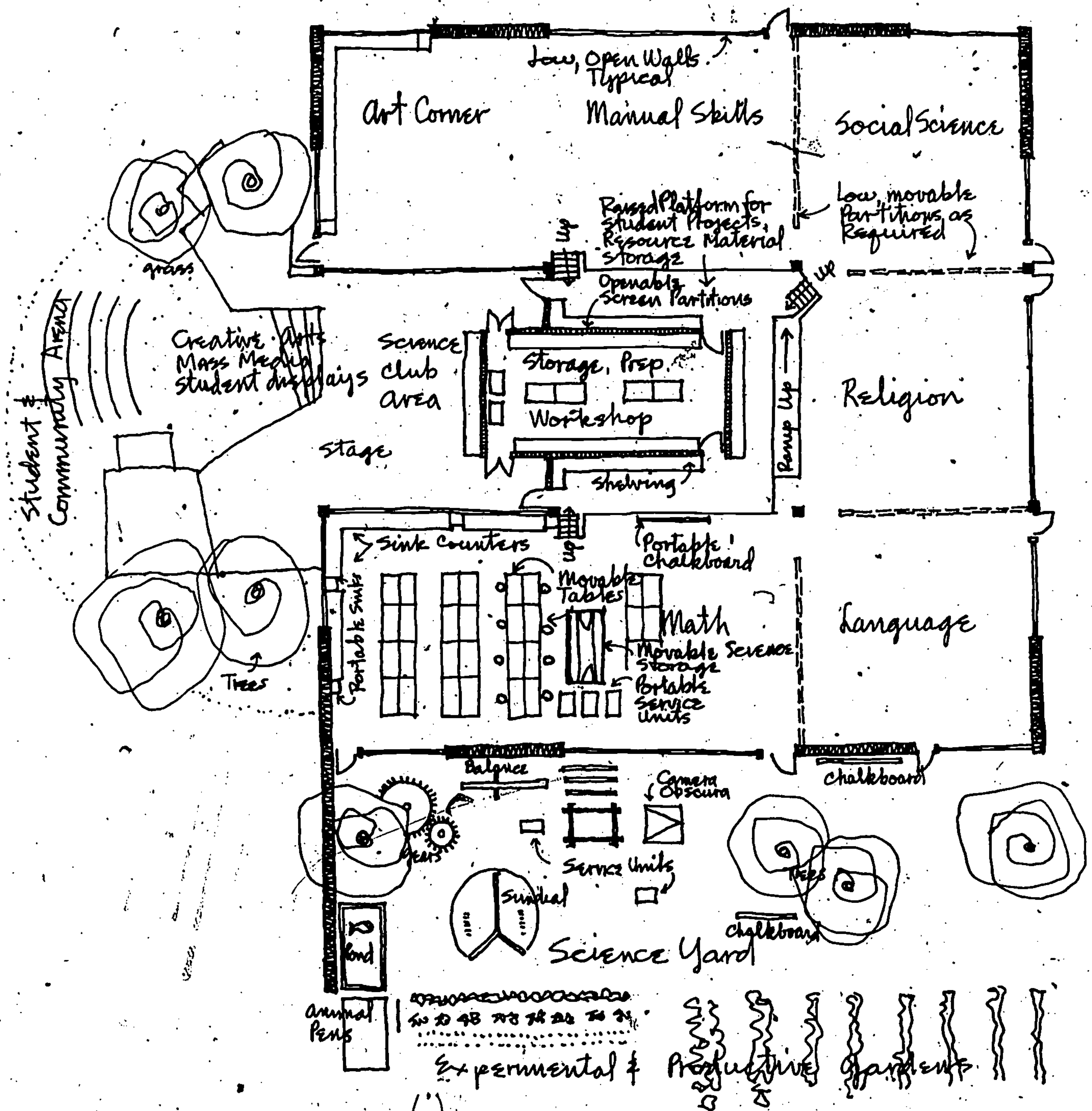
Existing Classrooms

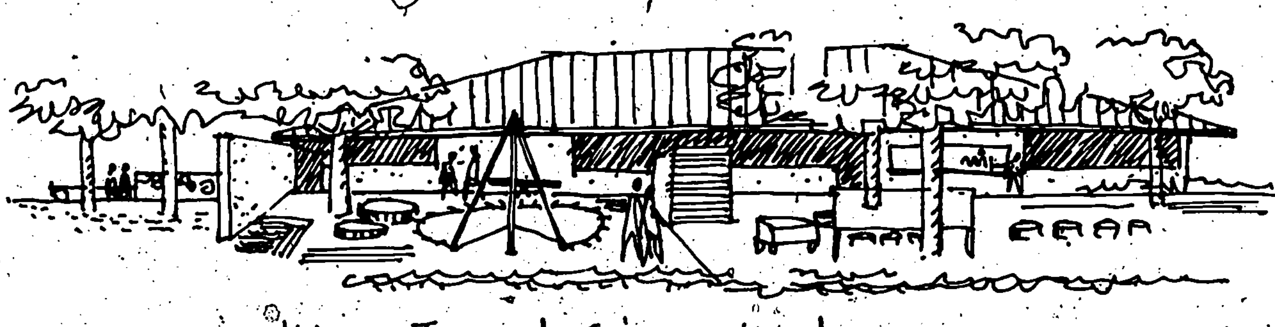


Remodelled Integrated Science Wing



Plan View of Lower Secondary School for 200
1:250

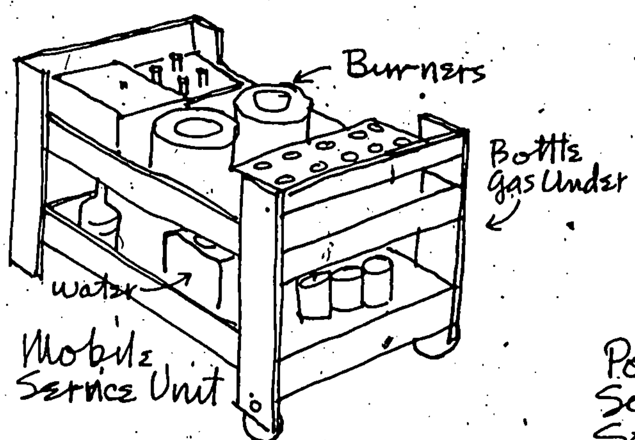




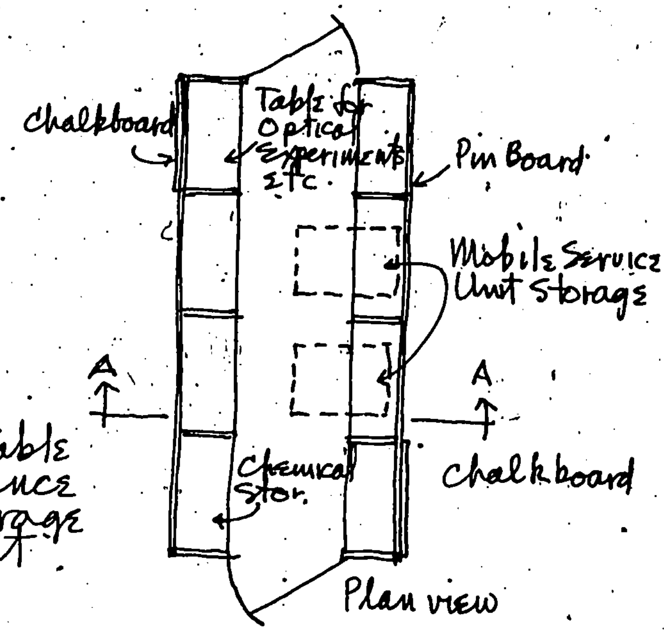
View Toward Science Yard

ERIC

Science Furnishings – Examples



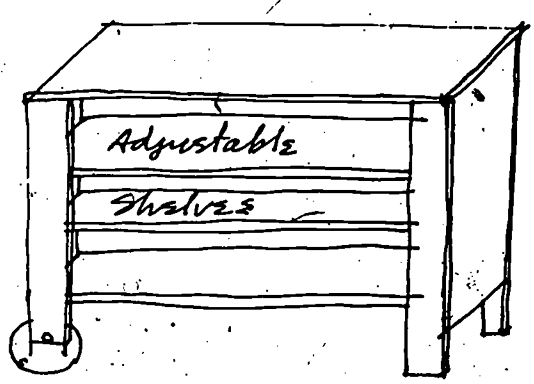
Mobile Service Unit

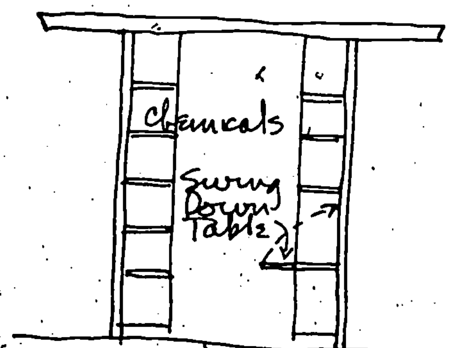


Portable Science Storage Unit

Plan view

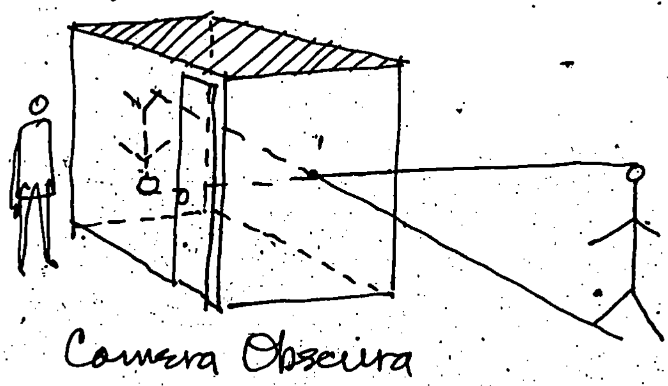
Mobile Work Bench





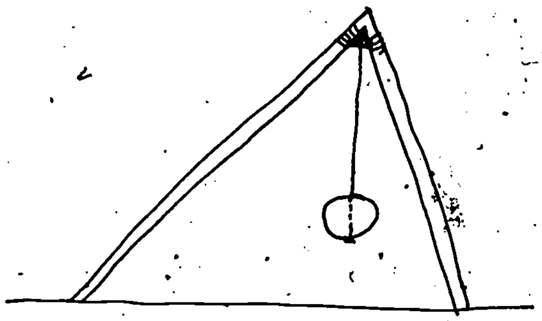
Section A

The above furnishings are illustrated and detailed in ARISBR publications



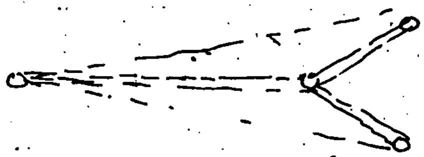
Camera Obscura

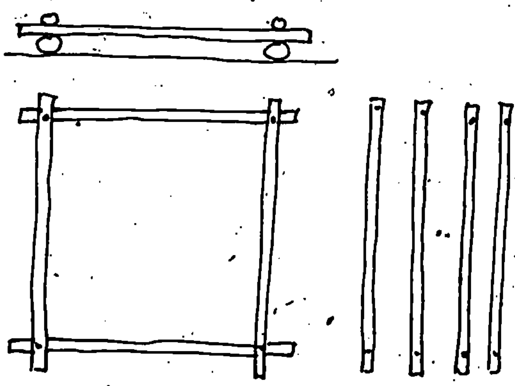
Typical Outdoor Teaching Aids



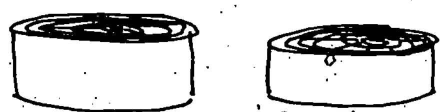
Tubular Sundial & Pendulum (metal or wood)

Balance - lever
See-Saw



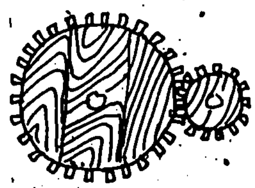


Static force Study frames



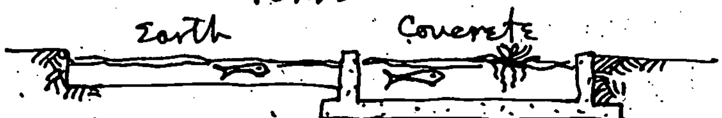
Tree Stumps - Plant growth - age

Walls of different stones

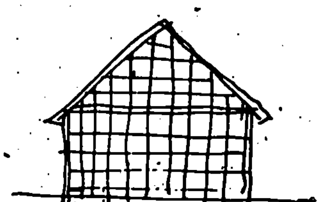


Wooden Gears

Ponds

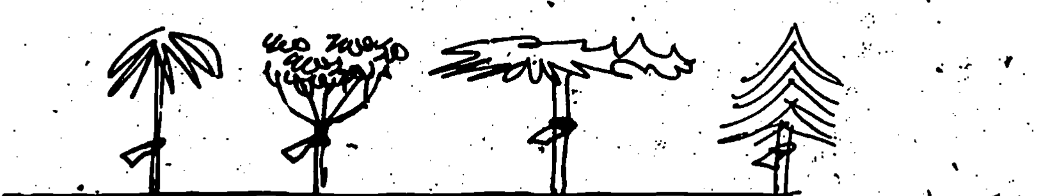


Ponds - fish, plants, displacement exercises



Animal Cages

Plant growth - Nutrition



Identification of Trees, shrubs, etc

V. TEACHER EDUCATION FOR THE INTEGRATED APPROACH TO SCIENCE TEACHING

1. Aims

Education has for too long been concerned with rote learning, stressing the accumulation of factual non-changing information. In a society undergoing social, economic and technological changes, people must be able to cope with these changes and seek desirable alternatives when necessary. It is apparent that the present system does not yet meet this need. An education is required that replaces rote, static and examination-centred learning with a dynamic process of preparing individuals for change and helping them to develop their self-concept (i.e. self-confidence plus a knowledge of one's limitations) and ability to think critically.

To this end we need to train teachers who will be agents of social and economic change. The training colleges must equip them with academic competency and understanding of the relevance of the education they acquire and transmit. They must be allowed to develop a commitment to, and enjoyment of the benefits of science for themselves first, and thus communicate this in their teaching.

The stress, however, should be to provide an environment in which the prospective teacher will be exposed over a long period to experiences in scientific processes of inquiry and situations which will promote the development of attitudes which complement those processes. There should be opportunities to understand the values of the various methods of working with children. These, coupled with an appreciation of child development, are invaluable in the process of encouraging the individual child to realize his full potential.

We should recognize that science education in our schools has the advantage of easily, and in a very natural way, using materials as the foundation for real and first-hand experiences in acquiring the necessary attitudes, knowledge and skills which are a prerequisite for the individual to function effectively as a member of his community. Emphasis should be placed on the importance of "doing science" and not "talking science".

As realistic outcomes, the practising teacher can be expected to regard his education as continuous, thus assuming the role of a co-learner in an ongoing process and presenting this attitude to his children. He will use the environment as resource materials for lessons in science and thereby develop creativity through AWARENESS OF NECESSITY. The concept of a dynamic curriculum, constantly undergoing change to keep pace with the society, should be present along with a commitment to effective teaching. The teacher must be an agent for change.

2. Objectives

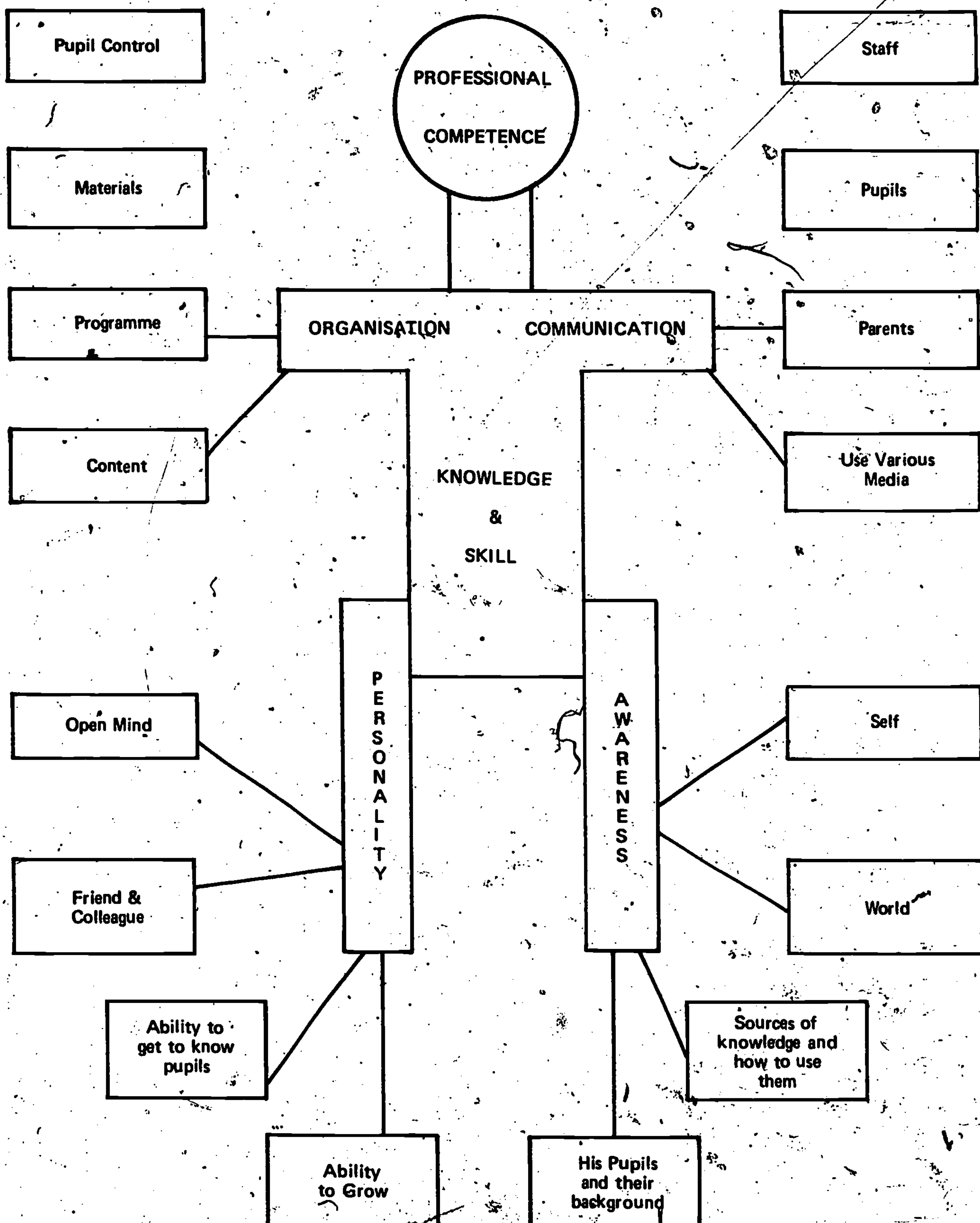
The general objectives of science teaching in the teacher training colleges may be listed under one of three headings:

Thinking processes
Attitudes and interests
Psychomotor skills

Thinking Processes to help student-teachers:-

i. To acquire scientific knowledge through the method of inquiry and experimentation.
ii. To promote an understanding of natural phenomena.
iii. To use local experience.
iv. To communicate with children.
v. To foster scientific ideas.

SOME ASPECTS OF A COMPETENT TEACHER



ERIC

Attitudes and Interests to help student-teachers:-

i. Provide an environment for children in which an interest in science can be fostered.
ii. Develop a spirit of independence, and an ability to solve their own problems; to assist primary school children to attain these same goals.
iii. Develop the awareness that the response of "I do not know" can be a valid answer to some questions posed by their pupils.
iv. Acquire the habit of careful observation.
v. Acquire the willingness to improvise.
vi. Develop the attitude of bringing into conscious and clear perspective, matters that would otherwise arouse no interest or understanding.

Psychomotor Skills

To enable the student-teacher develop certain manipulative skills. It was stressed throughout the discussion that the aims and objectives of the teacher training colleges should be selected so as to complement those of science education in the schools.

In order to initiate a programme designed to encourage the personal growth of the student-teacher as related above, the following is given as an example of suggested activities which might be spread over the initial period of the student-teachers' college life.

(i) During the first few meetings initiate relationships between themselves and yourself as tutor. Arrange them in an informal group, through discussions and activities to find out about themselves, the tutor and their new environment. This gives them a chance to become aware of themselves, what they have come to do, where they are, and what they can expect.

(ii) Take them out into their new environment which includes the college, local town or village, markets and other places of interest and activity. Attempt to make them aware of their environment by demonstrating at least one use of the environment, after which the student-teacher should be encouraged to select and develop his own example.

(iii) Give them the opportunity to participate in school life, not to teach, but to assist a competent teacher already in the school who will guide and direct their work. This is a time for the student-teacher to become aware of the child through interaction with him.

(iv) Provide the opportunity for the student-teacher to recognize the need to know more of the child and the environment.

With the above approach the student-teacher will be better prepared to understand and experience the importance of providing learning situations which try to develop the full potential of the individual through participating in activities.

The following exercise, Discovering Puddles, was developed to illustrate how a topic approach can be multi-disciplinary, or in this case inter-disciplinary, in the sciences. Its actual use is open-ended in that the depth of the investigation is directly dependent upon the background knowledge, and skills of the individual investigators. Therefore, it might be used at the primary school level, teacher training level, or the doctoral level. In this instance, it was used as a vehicle to explore possible models for educating preservice and inservice science teachers.

DISCOVERY OF PUDDLES

ITEM OF INTRIGUE:

Manufacture one or more puddles (small pools of water) if none are immediately available outside. Place the puddles in a location in the room which allows for maximum observation by the participants. This should be done prior to the beginning of the session.

ERIC

IMAGINATION DEVELOPMENT

Exercise the creativity of the group by having them close their eyes and imagine a puddle they have seen in the past. Direct them to expand this visualization by giving their puddle the attributes of: size, shape, depth, colour, smell. Further expansion results from imagining activities centered in and around the puddle. Include floating or suspended objects as well as live organisms.

OBSERVATION

(Eyes open) Examine the provided puddle thoroughly. Compare the attributes with those of your imagined puddle. Think of how you would change your puddle. What would you add—What would you remove—?

To assure total verbal participation, ask each member to describe how his puddle differed from the puddle provided.

Record their puddle observations on the board.

REFLECTIVE THOUGHTS ABOUT PUDDLES

What questions can the group ask about the observed data?

COLOUR

What colour is the puddle?
What causes colour?
How can we change the colour?
Can we tell what is in water by colour?

DISSOLVING POWER

Can we add things to water that become invisible?
Are there any things in water that cannot be seen?
What could you add to water which would become invisible?

TEMPERATURE

Does the temperature of water effect the properties it has?
(boiling—ice)

EVAPORATION

Where does water go when it is heated?
How could you prevent water from disapearing?

CALORIC PROPERTIES

Why does it take so long for a fire to heat water, when it would immediately heat one's hand?

OPTICAL PROPERTIES

Why do things look larger when they are in the water?
Can water magnify the size of things?
What happens when a living organism's size is magnified?
Is it heavier?

LIVING ORGANISMS

What is the scope and size range of organisms that live in water?
How do puddles affect our health?

ORGANISM DESIGN

How is it possible for some organisms to live in water and some not to?
How can some organisms live part of their life on land and part of their life in water?

Can man live in water?
What would man need in order to live in water all of the time?

COMPARISON CLASSIFICATION

What kinds and types of puddles do you see throughout the day?

DEFINITION

Is a lake a puddle?
Is an ocean a puddle?
Is a river a puddle?
What is necessary before you can call something a puddle?

CHANGE

Do puddles change with time?
What factors cause puddles to change?

TYPES OF USERS

How many different types and numbers of organisms use puddles?

USERS

What uses do organisms make of puddles?

NO PUDDLES

How would a world be different if it had no puddles?
Do we need puddles in order to live?

WORLD VIEW

What do puddles have to do with us, our families, our country, other countries, our world?
Do some countries have more puddles than other countries?
Do puddles effect the way we live?

OUTER SPACE

Could there be puddles in outer space?
If there are no puddles in outer space . . . could we make some?

UNEXPLORED AREAS

What new types of puddles could man create?
What new uses could man find for puddles?

INVESTIGATIONS

Participants, after using their imaginations regarding puddles and actually observing the attributes of puddles and doing some reflective thinking on those attributes, are ready to attempt to answer some of the questions they have asked through experimentation.

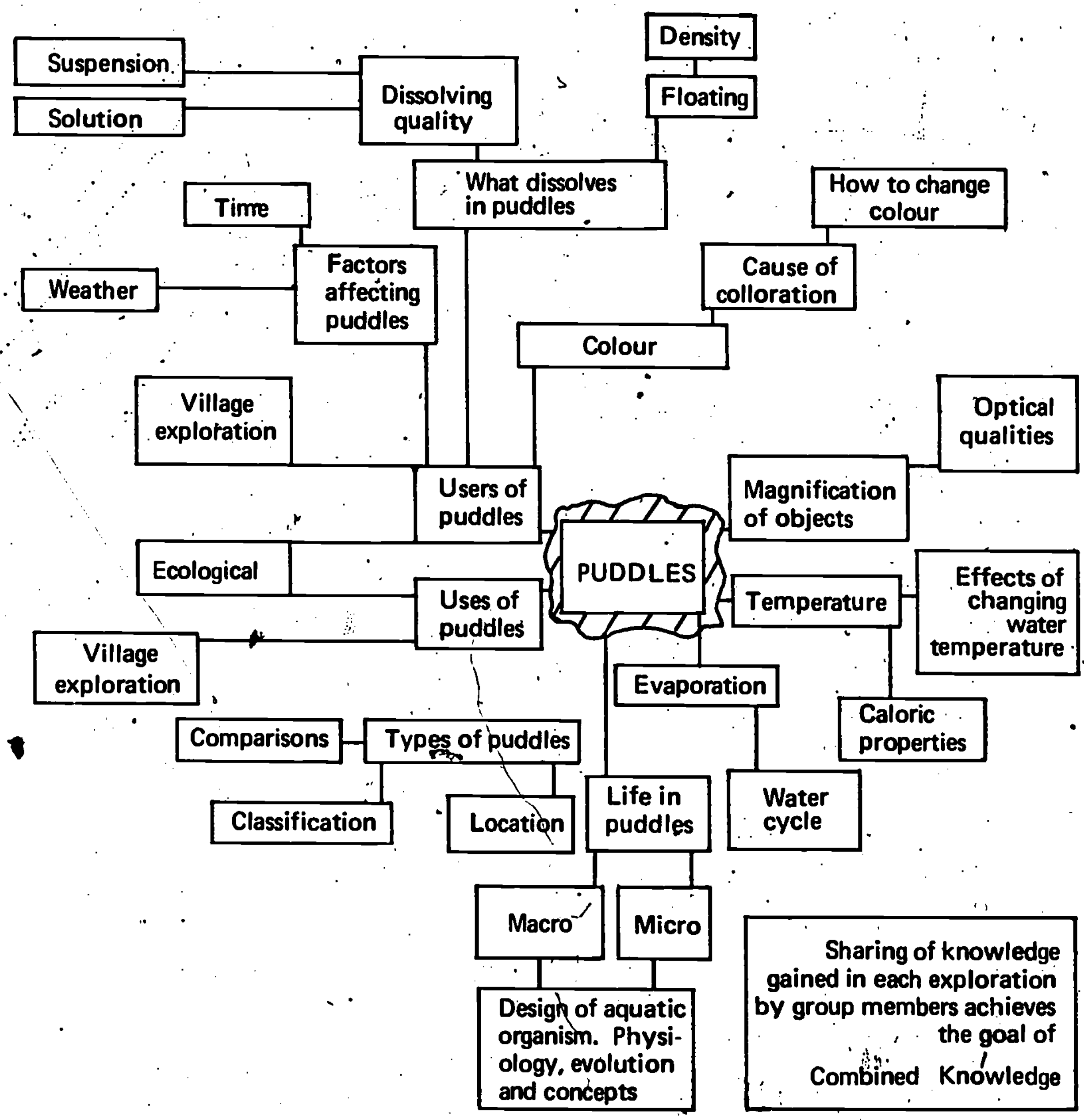
Assistance will be required to organize the many investigations. The sociology of puddles history, evaluation, mathematics, poetry, literature, etc. could also be correlated with the science investigations.

REPORTING AND EVALUATING

In this instance, participants were asked to examine the benefits students gain from sharing with their peers the results of their investigations. These should be presented in an oral and written manner, thereby allowing participants to increase their communication skills.

The entire experience allows for development in the areas of imagination, observation, questioning, design of experiments, evaluation of data, as well as an exercise of communication skills.

AREAS OF PUDDLE EXPLORATION



Combining the Topic and Process approach, allows exploration in all subject areas by a group, and the acquired knowledge is integrated into a framework of interrelationships that the group has explored.

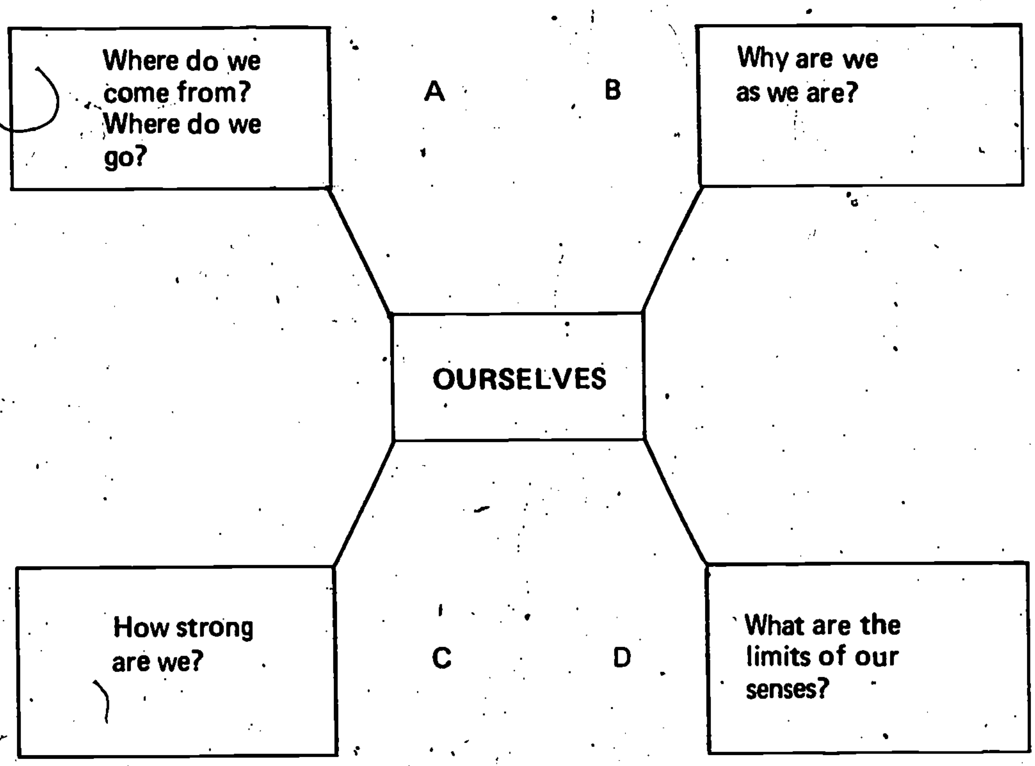
The milieu of these experiences should be such that they encourage future questioning, exploration, and association of ideas and concepts oriented toward the future.

Teacher educators need to examine each topic they choose in light of: learning theory, educational soundness, types of knowledge acquired, time, and equipment needed.

Puddle experiences is an abbreviated illustration of what can be done with nearly any topic. Teachers could also choose topics in such a way that they emphasize particular areas of science more than others. Thus a well rounded topic approach would expose the student to all areas of science.

An example of a more structured approach which might be used in the education of teachers of Integrated Science for the junior classes of Secondary Schools.

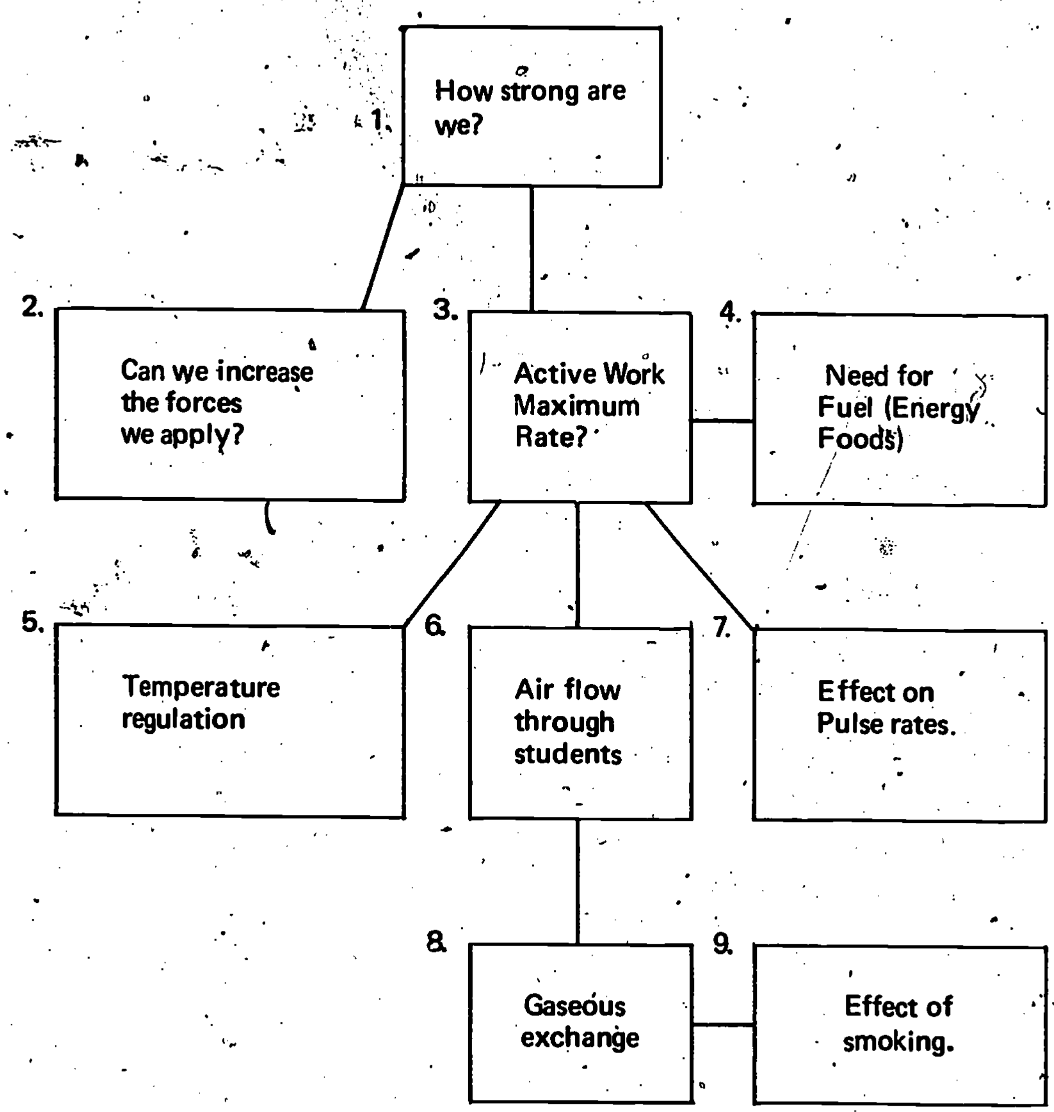
The starting type of such a topic would be the students themselves.



A,B,C,D, are four possible key questions, any one of which might be extended as far as the student and teacher educator may wish.

ERIC

For example consider an extension of D. 'How strong are we?'



Section D 1 ('How strong are we?') may include such investigations as:-

1. What is the maximum force we can exert between finger and thumb? (Who is the biggest pincher?)
2. Who has the strongest grip? What is the value of the force applied? Is grip related to our performance as a games player?
3. Who has the strongest hug?
4. What is our maximum pushing force?
5. What is our maximum pulling force?
6. What force can we exert with our leg? Is this force the same for the left leg as it is for the right?

Students at this stage will be obtaining a real feeling for forces and an appreciation of their magnitude in NEWTONS.

7. Can we make our own standard Force Measurer, and a Push–Pull measurer?
Students would make these two instruments from local materials (i.e. we are improving their psychomotor skills).

8. Use the instruments made above to investigate ten common pushes and pulls that we exert in everyday life.
9. The earth's pull could now be investigated.
   (i) Let a block fall to the ground. Why does the block fall?
   (ii) What is the value of the earth's pull on the block?
   (iii) Would the moon's pull on the block be more; the same; or less?
   (iv) Would the earth's pull on the block be the same all over the earth?
   (v) What is the earth's pull on this chunk of matter labelled 2 kilograms?
   (vii) What would the moon's pull on the chunk of matter be?
   (viii) Would the chunk of matter be different on the moon? i.e. will there still be 2 kilograms worth?

In the above the students would be differentiating between MASS and WEIGHT without using the words.

The models of teaching approach given above illustrate a distinction between a less structured and a more structured approach to teaching using an integrating theme. The models can be used and developed in the preparation of teachers for either the primary or secondary school. However the latter model was developed to illustrate a probable teaching approach at the lower secondary level.

It was felt that the step towards integrating the sciences was towards the integration of the school curriculum as a whole. This represents an exciting idea for future curriculum development in the secondary school and it is perhaps exemplified in the model of the school building found earlier in the report.

In order to prepare teachers of integrated science, a course could be structured so that the student-teacher follows a Foundation Science course for say the first half of his time in college, and this would be followed by an in-depth course in a subject area of his own choosing which would itself emerge from the Foundation Course. This would achieve two objectives: (a) it would enable the student-teacher to appreciate the various aspects of the different sciences, whilst at the same time, (b) give him the satisfaction and self-confidence that comes from a study of an area of science in some depth.

The broad-based exposure to science through experience, or the Foundation Course, would be taught in such a way that the content and methodology would be integrated, whilst the general educational courses, e.g. philosophy of education, would be catered for elsewhere.

In-Service Education for Teachers

Introduction

The above ideas mentioned in connection with pre-service education are also applicable to in-service education. Therefore, we should strive to make it possible for the two areas to complement each other. This could take the form of strengthening already existing links and at the same time encouraging the formation of new ones.

It is evident that the education of teachers is not terminal but a continual on-going process, and to this end practising teachers should be brought into contact with new ideas and recent educational developments through their participation in in-service courses, seminars and work-

shops, whose aim is to increase their competence in the classroom.

One of the important objectives of in-service education is to provide opportunities for teachers to reflect upon their own attitudes and teaching methods with a view to improvement.

Constraints

1. A Weak Knowledge Base.

One of the objections to teaching integrated science by teachers is very often the fact that their own knowledge in science is not broad enough to make them feel competent to teach it. Since many teachers would have studied only one or two of the sciences as Physics, Chemistry, Biology, Botany or Zoology, they feel that their own knowledge is not adequate for a study such as integrated science, which tends to look at things and phenomena from a multi-disciplinary point of view.

Again teachers in the past have not acted as if they have any contribution to make to curriculum improvement, Syllabuses and study schemes have come to them from officials outside the school. Teachers in this situation will either openly resist the adoption of such schemes or subvert their implementation. Teachers in the classroom should be fully involved at every stage of the projects. Teachers, tutors, university men and ministry officials who have helped with planning and carrying out the pilot projects should also help to carry out the in-service training of teachers.

Bureaucratic Administration/Institutional Commitments

Where ministry officials and other supervisory staff have not been reached, they may become subverting agents. It could be that these are people who believe in bureaucratic administration or institutional commitments. They know of a set way of doing it and will insist on or expect that. Thus education officers not reached will conclude that the integrated approach they see in a classroom is wrong and that teachers should do physics or chemistry or biology, etc. During in-service education such officials should be invited to participate and, if this practice is followed, it may effectively win them over to the new ideas being propagated. By encouraging such participation they could effectively put their weight behind the integrated science teaching through their supervisory work.

External terminal examinations are often rigid in their demands, and it is not easy to encourage students to adopt the integrated approach. It is therefore necessary to ensure that the examination at the end of the integrated science course is changed from what it is now to an examination which takes cognizance of the integrated approach. From the outset of the introduction of the new approach the Ministry and Examination Authorities should be encouraged to allow the appropriate kind of new examination.

Lack of Incentives or the Desire for Change

Absence of the appropriate examination for integrated science will make any in-service courses for integrated science purposeless, and teachers may not be interested. In addition is the problem of the lack of any financial or status incentive. Teachers, however interested, often use their vacations to go on in-service courses. To go to these courses without any hope of gaining financially or by way of promotion is asking a little too much of teachers.

Absence of Change Agent

There are many schools who will not be reached by the integrated science teaching for as long as in-service education has not reached them. The desired change will only occur when the agents of change are introduced into the system. Agents of change are being prepared.

Through in-service education courses, the agents of change can be injected into the educational system.

Insecurity and Regression

To tear any human being from the familiar things he knows to do best, naturally causes a certain amount of insecurity. Thus at the earliest chance such a person will abandon the new thing and revert to the old he knows well. In-service courses do help destroy or reduce this insecurity.

Experience has however shown that if after in-service courses teachers are not followed up then much of the effect of the training is lost and teachers sooner or later revert to their old ways. In short, in-service courses are useless if there is no effective follow-up.

(In the preparation of the above on in-service education, reference was made to "Introducing Innovations—Gaining Acceptance of Change" J. Kusi-Achampong, 1971 unpublished)

VI. EVALUATION

The necessity for evaluation: The introduction of any curriculum into a school system involves making a number of decisions. In order that such decisions may be taken on a rational bases, it is necessary to have information of various kinds which can provide such rational bases. Evaluation is necessary for the provision of such information. In fact evaluation may be defined as **the process of ascertaining the decisions to be made, selecting related information, and collecting and analyzing information in order to report summary data useful to decision makers in selecting among alternatives.+**

Suggested Framework For Curriculum Evaluation

Two broad but not mutually exclusive dimensions of evaluation must be considered.

1. Evaluation of the Programme
2. Evaluation of the achievement of the individual child in the programme.

The second dimension is necessarily involved in the first.

Evaluation of the Programme

Two kinds of evaluation are needed here.

(a) **Formative evaluation:** i.e. the kind of evaluation designed to aid the development of materials and help the process of decision making with respect to feed back from trials.

(b) **Summative evaluation:** i.e. the kind of evaluation that gives judgement as to the value or worth of the finished product. Irrespective of the kind of programme, three aspects need to be evaluated.

(i) **Antecedents:** These are the various conditions existing prior to the introduction of the new materials. These may include such things as the cognitive styles of the children, the socio-economic background of the children, the administrative structure of schools, the locality of schools, available resources in terms of funds, materials and man power.

Evaluation of antecedents calls for basic research into these various factors. Knowledge about them is vital to the decision-making processes in selecting and developing curriculum materials.

(ii) **Transactions:** These are the various strategies by which the programme is being carried out, for example the nature of materials produced, Teacher-Class-Material interaction, teacher training procedures, and administrative strategies.

(iii) **Outcomes:** These are in general the consequences of the programme. Such outcomes may have to do with the acquisition of skills and knowledge by the child, general intellectual development of the child and the impact of the programme on society at large.

An outline framework is shown in the accompanying table.

+ Alkin, Morvin C, A frame-work for evaluation Study: UCLA, Graduate School of Education, Los Angeles, California, U.S.A. 1969.

TABLE
A FRAMEWORK FOR CURRICULUM EVALUATION

	Variables	Intents/ Assumptions	Observation (Instruments & Techniques)	Judgement/ Decision
Antecedents	1. Manpower - Quality, Qualifications Predispositions 2. Children Intellectual ability, Socio-Economic Background Cognitive Styles 3. Learning Environment - School setting Administration Economic resources, Cultural setting		1. Surveys 2. Direct Observation 3. Tests	
Transactions	1. Instructional Materials - nature; Developmental strategies 2. Instructional techniques - Teacher Child-Material interaction 3. Supportive Strategies - Teacher training Interaction with policy makers. Interaction with Resource people 4. Intervention Strategies	DESCRIPTION	1. Direct observation using Observation Instruments e.g. Interaction analysis 2. Statistical techniques e.g. Readability indices 3. Surveys	SUBJECTIVE
Outcomes	1. The child) Cognitive 2. The Teacher) Effective 3. Parents) Psychomotor 4. Curriculum Innovators) Life 5. Educational Admin. & Policy 6. Economic Implications		1. Tests 2. Direct Observation 3. Surveys 4. Statistical Techniques e.g. Cost - Effectiveness Analysis 5. Controlled Studies	

In each case a list of the variable which concern the evaluated is listed. Given the variables under these three broad categories, there are three categories of information that need to be collected about them. These are:

(a) **Intents/Assumptions:** These are essentially the bases on which the curriculum development programme was embarked upon in the first instance. Collecting information here involves mainly a process of description.

(b) **Observations:** The extent to which intents are realized and assumptions justified can only be determined by actual observation carried out on the variables in question. It is essentially in this operation that the use of specialized measurement and evaluation instruments and techniques are called for. A list of such instruments and techniques is given.

(c) **Judgement/Decision:** The purpose of comparing observations with intents is to provide a rational basis for making judgements and taking decisions. The process of decision making may involve pooling and arrangement of information from other boxes in matrix but the eventual judgement or decision is essentially a subjective one.

Evaluation of the achievement of the child

This again may be of two kinds:

(a) **Guidance - oriented evaluation:** This is meant to identify the child's need for help and guidance in working within the curriculum.

(b) **Selection - oriented evaluation:** This includes yearly examinations to determine who gets promoted to the next class, or end-of-course examinations to determine who gets the primary school leaving certificate.

Guidance - oriented evaluation is no doubt the most important form of evaluation from the point of view of the child's education. However, both kinds of evaluation must be considered specially because the present situation in most countries is such that selection-oriented evaluation plays a vital role in the child's life.

There is of course the grave danger that techniques designed for evaluating the child's achievement can compel teachers to work along certain rather narrow lines. It is therefore important that techniques and instruments designed for integrated science should be seriously considered by specialists in the field of evaluation to ensure that the open, inquiry-oriented learning situations which proponents of integrated science teaching advocate are not obstructed by the process of evaluation. The accomplishment of this task may involve

(a) the running of special evaluation workshops;

(b) the involvement of specialized testing agencies such as TEDRO (Test Development and Research Office of the West African Examinations Council) and test specialists from universities;

(c) the establishment of test item banks which can serve the needs of classroom teachers.

VII. A PLAN FOR FUTURE ACTION FOR INTEGRATED SCIENCE TEACHING IN ENGLISH-SPEAKING AFRICAN COUNTRIES

Plans for future action must encompass both national and regional activities; such activities are complementary. While national activities can be greatly strengthened and improved through regional inputs, regional activities can only be successful when they draw on soundly based national experience.

1. As a follow-up to the present Workshop and to the Nairobi Workshop which preceded it, the reports of the two workshops should be widely disseminated. They should be used as basic documents in planning the Conference for the Application of Science and Technology in Africa (CASTAFRICA). National workshops should be organized at which these two reports are discussed and used as a basis for national planning for integrated science teaching, particularly in the context of rural development.

2. An exchange of information is needed. This will involve the establishment of a clearing house for information. The Science Education Programme for Africa (SEPA) and the UNESCO field Science Office and Regional Education Office should collaborate in this programme, particularly through the publication of newsletters and bulletins. Evaluation of integrated science teaching programmes is an area where, in particular, a greater flow of information is desirable. The exchange of information among science teachers associations in Africa should also be promoted in all possible ways.

3. A programme for the further education of teacher educators in integrated science teaching is very desirable. A joint SEPA - UNESCO - CEDO programme should be established for this purpose.

4. To ensure concerted action among the various groups involved in science education at the national level (curriculum development group, science teachers associations, teacher training colleges, university scientists, science educators, etc.) a national co-ordinating body is necessary. A National Curriculum Development Centre can act as a focal point for the development of science teaching materials. Teachers centres linked with the National Centre can promote the local development of materials and the initiation of teachers in their use.

5. Science teaching equipment poses particular problems for the on-going development of integrated science teaching. Countries should establish national centres for the production, maintenance and repair of school science equipment. UNESCO assistance may be sought for this purpose. These centres should be closely linked with the on-going curriculum development activities in integrated science teaching at the national level.

6. One or more pilot projects in school buildings for integrated science teaching in Africa should be established through the agency of the UNESCO Regional Educational Buildings Institute for Africa (REBIA), Khartoum. Such projects should be established in countries which already have well-developed integrated science teaching programmes.

7. Several international and bi-lateral agencies are assisting integrated science teaching in Africa. Where co-operation between them is established, progress will be more rapid. These organizations should seek actively to work together to provide "integrated aid".

8. There is the need for more regional and sub-regional Workshops. SEPA should collaborate with UNESCO and UNICEF and with bi-lateral aid organizations in the planning, organization and follow-up of future Workshops. In particular, evaluation workshops linked with integrated science teaching programmes should be organized at international, regional and national levels with multi-lateral and bi-lateral aid. Such workshops should be concerned with the construction of sample evaluation instruments and with the training of indigenous personnel.

ANNEXES

I. List of participants

II. Workshop programme

III. List of papers presented

IV. Messages of welcome presented at the opening ceremony

V. Keynote address

ANNEX I

PARTICIPANTS AT THE WORKSHOP

National Participants

BOTSWANA	Mr. K. G. Kgoroba Lobatse Secondary School Private Bag 13, Lobatse
ETHIOPIA	Mr. Telahoun Haile Curriculum Department Ministry of Education P. O. Box 1367, Addis Ababa
GAMBIA	Mr. C. W. Cole Principal Education Officer Education Department Bathurst
GHANA	Mr. S. M. Adu Ampoma Principal Education Officer Ministry of Education P. O. Box M. 188, Accra
KENYA	Mr. Fanuel Wakhu Kenya Science Teachers College P. O. Box 30596, Nairobi
	Mr. L. E. Ngugi Ministry of Finance and Planning P. O. Box 3000-7, Nairobi
LESOTHO	Miss E. O. Morahanye Peka High School P. O. Box 17, Peka
LIBERIA	Mrs. Theodora Ward Jackson Teachers College University of Liberia, Monrovia
MAURITIUS	Mr. Ramdeen Goorah Ministry of Education and Cultural Affairs Government House, Port Louis

NIGERIA	Mr. J. M. Akintola Federal Ministry of Education, Lagos
	Mr. T. A. Balogun Faculty of Education University of Ibadan, Ibadan.
SIERRA LEONE	Dr. Magnus Cole Njala University College, Njala
SOMALI REPUBLIC	Mr. O. J. Dahir College of Education, Mogadiscio
TANZANIA	Mr. E. Mushi College of National Education Box 691, Morogoro
UGANDA	Mr. I. K. Bagarukayo P. O B. 152, Mukoni, Kampala
ZAMBIA	Mr. S. M. Chellahs Mufulira Teacher Training College P. O. Box 400, Mufulira

Unesco Experts associated with Unesco/UNICEF-assisted projects or Unesco Science Education Projects.

Mr. R. C. Lang
Unesco Science Teacher Training Adviser
Ministry of Education
P. O. Box 39, Mbabane, Swaziland

Mr. N. K. Lowe
Unesco Science Teaching Equipment Adviser
P. O. Box 2823, Lagos, Nigeria

Mr. G. N. Sharma
Unesco Science Teaching Adviser
Ministry of Education, Benin City, Nigeria

Mr. G. D. Sharma
Higher Teacher Training Institute, Omdurman
Khartoum, Sudan.

Mr. A. C. Tosh
Unesco Teacher Training Adviser
P. O. Box 9182, Dar-es-Salaam, Tanzania

Unesco Regional Educational Building Institute for Africa (REBIA)

Mr. Richard C. Marshall (Unesco Adviser)
Unesco-REBIA, Khartoum, Sudan

Consultants

Mr. D. G. Carter
King Alfred's College of Education
Winchester, U. K.

Dr. Hubert Dyasi
Science Education Programme for Africa
P. O. Box M. 188, Accra, Ghana

Observers

Africa Primary Science Programme

Mr. J. Seawell
P. O. Box M. 188, Accra, Ghana

The British Council

Mr. B. J. Carroll
British Council, Western House, Lagos, Nigeria

Mr. David Bates
British Council, P. O. Box 771, Accra, Ghana

Centre for Educational Development Overseas (CEDO), U. K.

Mr. D. G. Chisman
Deputy Director, CEDO
Tavistock House South
Tavistock Square
London W. C. 1, U. K.

The Ford Foundation

Mr. Ross E. Bigelow
The Ford Foundation
Box 2368, 747, Marina, Lagos, Nigeria

International Development Agency Project, Sierra Leone

Mr. J. R. Hill
Science Education Adviser
Curriculum Revision Unit
I. D. A. Education Project
c/o British Council, P. O. B. 124, Freetown

Observers from Nigeria

Mr. I. J. Adenuga
Ibadan Grammar School, Ibadan

Mr. B. E. K. Briggs
Ministry of Education, Rivers State, Port Harcourt

Mr. P. Dastoor
Chemistry Department, University of Ibadan

* Prof. B. Fafunwa
Deputy Vice-Chancellor
University of Ife, Ile-Ife

Mr. A. A. Ibegbulam
Nigerian Educational Research Council
Federal Ministry of Education, Lagos

* Keynote speaker

Mr. E. A. Ifezulike
Government Secondary School
Afikio, Enugu

Mr. I. O. Ekeobi
International School
University of Ibadan

Mr. A. McBrown
Ministry of Education, North Central State, Kaduna

Mr. U. D. Mairiga
Government Secondary School
Lafia, Benue Plateau State

Mr. J. O. Molomo
Ministry of Education, Western State, Ibadan

Mr. I. R. Murray
University of Ife, Ile-Ife

Mrs. I. R. Murray
University of Ife, Ile-Ife

Dr. K. H. Niedfeldt
Dept. of Education, Ahmadu Bello University
Zaria, North Central State

Mr. S. O. Odunfa
St. Andrew's College, Oyo

Mr. E. O. Ogunyemi
Dept. of Education, University of Ibadan

Mr. T. O. Ohikhena
Dept. of Education, University of Ibadan

Mr. K. A. Olaniyan
Federal Ministry of Education, Lagos

Mr. D. Oyewole
President, Science Teachers Association of Nigeria
West African Examinations Council, Yaba

Mr. O. Ryan
International School, University of Ibadan

Rev. P. S. Samuel
Secretary, Science Teachers Association of Nigeria
International School, University of Ibadan

Mr. G. A. Ugwuegede
Ministry of Education, East Central State, Enugu

Dr. E. A. Yoloye
Dept. of Education, University of Ibadan

Mr. John Whee
Institute of Education, University of Ibadan

Workshop Co-ordinator

Mr. L. E. Folivi
Federal Ministry of Education, Lagos

Unesco Secretariat

Dr. N. S. Rajan
Unesco Chief of Mission
c/o Ministry of Education, P. O. B. 2823, Lagos, Nigeria

Dr. O. Ibukun
Director, Unesco Field Science Office for Africa
Unesco House, P. O. B. 30592, Nairobi, Kenya

Mrs. Sheila M. Haggis
Programme Specialist
Division of Science Teaching, Unesco, Paris, France

ANNEX II

WORKSHOP PROGRAMME

Normally three 2 hour working session were held per day as detailed below

Session	1	8.30 a.m. - 10.30 a.m.
"	2	11.00 a.m. - 1.00 p.m.
"	3	3.00 p.m. - 5.00 p.m.

Monday, September, 20th

Session 1. (P)*

8.00 a.m. - 9.00 a.m.	Registration
9.00 a.m. -10.30 a.m.	Opening of Workshop by Mrs. F. Akintunde-Ighodalo, Permanent Secretary, Western State of Nigeria Ministry of Education, Chairman, Mr. J. M. Akintola, Federal Ministry of Education, Nigeria, Keynote address, Prof. B. Fafunwa
2. (P)	
11.00 a.m. - 1.00 p.m.	Discussion of keynote address Presentation of country programmes by national delegates
3. (P)	
3.00 p.m. - 5.00 p.m.	Presentation of country programmes by national delegates (continued).
6.30 p.m. - 8.00 p.m.	Cocktail Party.

* P = Plenary session, G = Working Group session

Tuesday, September, 21st

Session 1. (P)	The concept of Integrated Science Teaching - Mrs. S. M. Haggis
	Integrated Science Teaching - Examples of Current Programmes - Mr. D. G. Chisman
2. (P)	Curriculum Development in Integrated Science Teaching — Primary level — Dr. Hubert Dyasi
3. (P)	Presentation of country programmes (continued)

Wednesday, September, 22nd

Session 1 and 2 (V) Visits to schools, training colleges etc. in Ibadan.

Thursday, September, 23rd

Session 1. (P)	Development of integrated science teaching materials — Dr. Magnus Cole.
2. and 3. (G)	Working groups.

Friday, September 24th

Session 1. (P)	Teacher training for integrated science—pre - service courses—Mr. D. Carter
2. (G)	Working groups
3.	Visit to Exhibition of science teaching books and equipment

Saturday, September 25th

Session 1. (P)	Science teaching equipment, production and distribution—Mr. R. Marshall and Mr. N. K. Lowe
2. (G)	Working groups

Sunday, September, 26th—Free

Monday, September, 27th

Session 1. (P)	Teacher training for integrated science—in - service courses—Mr. S. M. Adu—Ampoma
2. (G)	Working groups

Tuesday, September 28th

All day visit to Aiyetoro Comprehensive High School and to Mayflower School Ikenne

Wednesday, September, 29th

Session 1. and 2; (P) Evaluation of integrated science courses—Dr. E. A. Yoloye
3. (G) Working groups

Thursday, September 30th

Sessions 1. 2. and 3 (G) Working groups. Finalization of group reports

Friday, October 1st National Holiday

Saturday, October 2nd

Sessions 1, 2 and 3 (P) Presentation of group reports

Sunday, October 3rd Free

Monday, October 4th

Sessions 1, 2 and 3 (P) Presentation of final report
Closing ceremonies.

ANNEX III

LIST OF PAPERS PRESENTED TO THE WORKSHOP

Reports on the status of science teaching at primary and lower secondary levels from each of the following countries:

Botswana
Ethiopia
Gambia
Ghana
Kenya
Lesotho
Liberia
Mauritius
Nigeria
Sierra Leone
Somali Republic
Tanzania
Uganda
Zambia

Keynote Address: "Premature Specialization in Science Education, A Dis-service to Developing Nations"—Prof. B. Fafunwa

The Concept of Integrated Science Teaching—Mrs. S. M. Haggis

Unesco's Programme in Integrated Science Teaching—Mrs. S. M. Haggis

The Science Education Programme for Africa: An approach to Educational Development—Dr. H. Dyasi

Integrated Science Projects in the U.K.—Mr. D. G. Chisman

Development of Teaching Materials for Integrated Science—Dr. Magnus J. A. Cole

Some First Ideas on the Pre-Service Training of Teachers of Integrated Science—
Mr. D. Carter
Teacher Training for Integrated Science—In-service courses—Mr. S. M. Adu—Ampoma
Multi-Purpose Laboratories Suitable for the Lower Classes of African Secondary Schools and For Primary Teacher Training Courses—Mr. Richard Marshall.

ANNEX IV

MESSAGES OF WELCOME PRESENTED AT THE OPENING CEREMONY

An Address of Welcome Presented By
Mrs. F. M. Akintunde-Ighodalo
Permanent Secretary, Western State of Nigeria
Ministry of Education.

Mr. Chairman, Ladies and Gentlemen,

It is a pleasure, indeed a great privilege, for me to be invited to perform the formal opening of this workshop which has brought together 14 English-speaking African Countries. Nigeria (and Ibadan in particular) considers itself fortunate to have been chosen as the venue for this great gathering. May I seize this opportunity, on behalf of the people of this country, to welcome you to Nigeria and hope that your stay will be very fruitful one.

One does not require a sermon to appreciate the fact that the days when school subjects were in different water-tight compartment are over. Man has come to appreciate the unity of knowledge and interdependence of these subjects on one another. Biology is becoming more and more involved with Chemistry; it is becoming increasingly difficult to draw a fine line between Chemistry and Physics, while Physics is fast becoming more mathematical. The need for an integrated science programme therefore cannot be gainsaid. This is why the efforts of the United Nations Educational, Scientific And Cultural Organisation (UNESCO) to organise this seminar is not only opportune but also very welcome.

There are several problems connected with the teaching of science as an entity, and these vary from one country to another. Individual countries must have been tackling these problems in their own ways and with varying measures of success. It is therefore gratifying that you will, among other things, exchange information on what has been done in your different countries at various times to produce and implement integrated science curricula. I am sure that it will also be useful, as I understand you will be doing, to review integrated science programmes in countries outside Africa with a view to developing integrated science teaching programmes that are suitable to our particular and peculiar background.

The problems which science teaching creates are of a universal nature and only vary in degree from country to country. In Nigeria, as in most developing countries, we are short of personnel for teaching of science, and the few that are available are very often the less experienced ones. This is largely because we cannot compete with industry, as the latter often offers more attractive salaries. This rapid turnover makes continuity of teaching difficult. Another difficulty in the way of science teaching, especially for developing countries, is the inadequate supply of resource material.

It is gratifying therefore to know that at this conference you will deliberate extensively on how to make suitable textbooks and materials available for learning science in our schools.

Efforts by the UNESCO in trying to improve the lot of mankind especially in developing countries are highly appreciated. May I wish, therefore, to seize this opportunity to offer to the UNESCO the immense thanks of the Government and people of Nigeria in particular and of Africa in general for arranging this conference. This workshop is taking place as a result of the challenging conclusions of the 1968 UNESCO sponsored VARNA Congress on the Integration of Science Teaching. Part of the conclusions reached at that time say that:-

"The teaching of integrated science contributes towards general education, emphasizes the fundamental unity of science, and leads towards an understanding of the place of science in contemporary society . . .

"At the earlier stages of secondary education a totally integrated course in experimental science appears generally desirable . . . .

"Further experiments in the development of new integrated curriculum and the production of teaching materials are needed."

We in Nigeria have made a number of efforts to produce general science and integrated science programmes. In particular and with the assistance of the United States Aid For International Development (USAID), the Ford Foundation and Harvard University, we have been able to produce a fairly suitable general science programme for the first two years of our secondary schools. Through the Comparative Education Study and Adaptation Centre (CESAC), programmes for the last three years are currently being written.

The different States are also working on Elementary science programmes, and in this latter respect, we have benefitted from experiences gained by our teachers from participation in African Primary Science Project (APSP), and other workshops organized by our universities and similar bodies. A number of other organisations have also responded very well to this challenge by establishing Curriculum Development Committees to draw up new syllabuses for the teaching of science in the lower forms of the secondary schools.

Particular mention must be made of the Science Teachers Association of Nigeria (STAN), the Comparative Education Study and Adaptation Centre (CESAC), and the Nigerian Secondary Schools Science Project (NSSSP)—Nuffield Foundation, the British Council, all which have both individually and jointly organised and supported curriculum improvement in science teaching in our schools. Representatives of these various organisations are at this conference and will no doubt cooperate in making it a success. The country very much appreciates the contributions which these organisations have made and are making towards the proper teaching of science in our schools.

The need to teach science is of such great importance for the developing countries of Africa. As developing countries we require the services of indigenous doctors, engineers, experts in various fields of learning who will make valuable contributions to the advancement of our nations. The foundations of these professions are laid in the science programmes of our schools and they will not have been properly laid if science is not well-taught.

If this conference must achieve any success at all, it will be in the preparation of a satisfactory and superior science programme. May I warn that a satisfactory and superior science education programme must have economic, political and cultural objectives so as to achieve the goals of the society for which education is planned. Poor developing countries with economic problems and inadequate man-power to cope with the technical problems which development introduces have aspirations which are constrained not only by the limits of

Address of Welcome by Professor G. M. Edington
Deputy Vice-Chancellor, University of Ibadan.

Chairman, Distinguished Guests, Delegates,

I have the greatest pleasure in welcoming you on behalf of the Vice-Chancellor, Professor T. A. Lambo, to the campus of the University of Ibadan. Professor Lambo expresses his deep regret at being unable to be present this morning but he is heavily committed elsewhere. I should like to say how honoured the University is to be the venue of this most important Workshop and we are grateful to the various UNESCO Agencies and to the Nigerian National Commission for UNESCO and to other supporting organizations for considering Ibadan a worthy host of this Conference. Our Chairman and Madam Permanent Secretary, Mrs. F. M. Akintunde-Ighodalo, have already said much that I myself intended to say. So I shall therefore keep this address as short as possible. We are delighted to have so many delegates from the English-speaking African countries visiting the University.

During the last five years, the idea of integrated science teaching has gained greater and greater prominence in the educational programmes of many countries of the world and I am delighted to say that the Science Teachers Association of Nigeria has been most active in this field. One cannot emphasise too highly the importance of science in the educational programme at all levels. More and more in countries in Africa is science being applied in various areas of industry and training in applied science is being undertaken at technological colleges and universities. It will be impossible for these institutions to successfully undertake such training unless a firm basis of scientific knowledge is laid at the primary and secondary school levels.

Different programmes have tended to identify different areas as being the common elements in science. Some have identified the common links in terms of "scientific concepts" like energy, systems, interactions, relativity, etc. Others have identified them in terms of "scientific processes" e.g. observation, classification, hypothesis formation, experimentation, interpretation of data, manipulating variables etc.

The result is that although there are various programmes bearing the label "integrated science", they often differ markedly in their content and have integrated their science in very divergent ways. Perhaps the one thing common to all is the emphasis they put on inquiry and practical application by the students.

The present conference is, therefore, serving a very vital function in providing a forum for exchange of information on the various programmes with a view to the overall improvement of science education.

Finally, I should like to welcome you all, once again, and I hope that you will have the opportunity of seeing something of our campus. A visit to our Library, Institute of African Studies and Bookshop should be well worthwhile. In addition to visiting historical Ibadan, I hope you will also have time to visit our sister University of Ife with its wealth of surrounding cultural objects. May I wish, on behalf of the Vice-Chancellor, your Workshop every success.

their resources, but are dictated by association with the more affluent nations whose style of living is appealing to citizens of developing countries.

The common dream of all developing countries is to be industrialised in the hope that this is the first step in a take-off to modernity. The tendency in the process of pursuing these dazzling goals is to make the regrettable mistake of forgetting the importance of Agriculture or relegating it to the far background in the planning and execution of their economic programmes. It is hoped that the holding of workshops and seminars like this one will go a long way to correct such imbalance in our planning.

It needs to be emphasized that science is fast changing the world. Every officer of government, every law maker is confronted with all sorts of scientific and technical development which affected the political, economic and social problems that are a government's main concern. A businessman no matter what his field is confronted everyday with technical and scientific break-through that may threaten him with disaster or hold out the promise of great achievement. Yet law makers and businessmen alike must turn for advice to technical people whose language they may not even understand. This means that our science programmes must prepare the genius and the future professional for his future undertaking, and yet provide the layman with enough understanding of the main essentials of science so that the process of communication between the expert and the people he is to serve can be meaningful and fruitful.

I have no doubt that in formulating whatever will be acceptable integrated science programmes for developing countries, you will not forget that we must set certain goals. Permit me to suggest that these goals must, among many others, foster humanistic, liberal and general education. It should aid the student to develop critical thinking through inquiry approach; help him to appreciate the ability of man to control his environment and adjust it to suit his aspirations and meet his needs. It must also foster the awareness of the people, both leaders and led, government and the governed, towards scientific and technological analysis of their problems and environments; and it should last but not the least, assist the students to develop their decision-making skills.

Ladies and gentlemen, Ibadan is a big city and a land of contrasts. I hope that while you are here you will find time to see what we can offer in the way of culture. We are very proud of our city and the little that we have been able to achieve. Please feel free to explore our lands and take back with you the goodwill of our people. You have before you a fortnight of purposeful activity and valuable discussion. This is a very heavy assignment and we look forward to reading the report of this conference.

Once more I welcome you all to Nigeria and to Ibadan in particular and wish you a very happy and fruitful stay.

Ladies and gentlemen, it is with the greatest pleasure that I now declare this workshop open.

Address of Welcome to the participants at the UNESCO/UNICEF Workshop on Integrated Science Teaching for English-speaking African countries, Ibadan, Nigeria, September 20th - October 4th, 1971. by Chief Stephen Awokoya, Director, Department of Science Teaching and Technological Education and Research, UNESCO.

Ladies and Gentlemen,

I regret that I am not able to be with you in person today to welcome you to this integrated science teaching workshop for English-speaking African countries. I feel that this meeting will be a land-mark in the development of science education in Africa. You, the representatives of 13 African countries are met together to carry out a kind of "stock-taking" of science teaching developments in the primary schools and secondary schools of Africa. Your particular task is to draw up a plan of action for the development of a science teaching which is suited to the needs of your pupils in the actual situations in which they are living.

You will be concerned with "integration" at this workshop. An integral is something which is whole. You are thinking about science as a whole as it effects the child in the totality of his environment. I like to think of integrated science at the lower levels of schooling as a kind of embryo which contains within it all that is necessary genetically to produce not only the future scientific and technological manpower required for development but also the good citizen in our modern age. Thus, integrated science teaching should provide a basis for the pupil who will become a citizen who needs to take decisions in matters deeply affected by science. This person might be a politician on whose decisions the fate of millions could hang. He might equally be an agriculturist, an architect, a physician, an engineer, a physicist, a chemist, a biologist, a mathematician, an economist, a bishop, a judge, or even a business man. Integrated science teaching, however, must have integrity. It must be linked with the whole of the school curriculum. It must be a stimulating experience in the scientific education of the child who will later become a scientist, or follow a science-based career. Even if he does little more, it should enable him to appreciate science for what it stands for today and in the future. In this connection, you may feel that the natural environment offers you an excellent approach; you may also feel that the technological application of science in modern society is equally a valid entrance; others may think that the combination of the different scientific disciplines is the real answer. Whatever your prejudices, integrated science should be integrated and have all those ingredients which will later evolve into the various disciplines.

It seems to me, therefore, that you have a double task: to be concerned with the contribution of science to general education in African children, while at the same time providing those basic skills which are essential as a foundation for more highly specialised training in the future.

I hope that in those two weeks you will have a rewarding and fruitful time and I look forward with every confidence to a valuable outcome of your endeavours.

S. Oluwole Awokoya,
UNESCO PARIS FRANCE.
September 15, 1971.

ANNEX V

Premature Specialisation in Science Education: A Disservice to Developing Nations

Key-note Address

by

Professor A. Babs Fafunwa
Deputy Vice-Chancellor
University of Ife
Ile-Ife

Chairman, Ladies and Gentlemen,

It is with considerable trepidation that I appear before this august body of scientists and science educators and administrators from seventeen countries to deliver the keynote address at this important international workshop on "Integrated Science Teaching". Although I did some science in school and at the University, I cannot claim to be a scientist either by trade or by profession. I am however a friend of science and scientists who are interested in finding solutions to the many problems that bedevil under-developed countries of the world particularly the African countries.

We are living in a world where Science and Technology have become an integral part of the world's culture and any country that overlooks this significant truism does so at its own peril.

We know that it was the practical application of the new discoveries in science and technology that was largely responsible for transforming the erstwhile under-developed or backward societies of the Western World into advanced states. It was also because of the speed with which these new phenomena were disseminated and proliferated that the West was able to gain a substantial lead over the rest of the world. It was the study and the application of science which brought economic and social benefits to mankind in general and to Europe and America in particular. These guaranteed them a high standard of living and improved the health condition of their people.

It would therefore be foolhardiness on the part of the non-Western World not to recognise science and technology as a dominant cultural factor in this late twentieth century. Dissatisfied with their own rate of growth, both Europe and America continue to seek newer ways of doing things; yet many of the first fruits of scientific and technological progress have not yet arrived in Africa and the new advances which have superseded the old are even farther from Africa's reach.

It is possible to exist with little or no knowledge of science. Indeed, millions of people in developing countries do just that. But it is almost impossible today to lead a full and satisfactory life with little or no knowledge of science. We of the under-developed countries must develop our human and natural resources to solve our economic problems. We need to improve our diet, improve our transport system, develop our mineral resources and control soil erosion. We must introduce modern scientific farming, control cattle diseases, improve their health programme and solve a myriad of other problems that call for scientific and technological dexterity. To achieve these, we must, as a matter of national

urgency, train as quickly as possible an army of competent teachers, scientists and technicians. We require also scientifically and socially orientated policy makers, as well as scientifically orientated citizens. Science in twentieth century has, without a doubt, become a necessary aid to good living and good citizenship, to health, agriculture, home making and leisure. For these reasons, therefore, science and technology must necessarily play a vital part in African education and the new school curricula. Every child and every future adult has to be reached.

To achieve this, the foundations must be laid at all levels of education through both general and special education. By general education, in this context, we mean a broad type of education aimed at developing the attitudes, abilities and behaviour considered desirable by society. As far as science and technology are concerned, it is attitude that matters. It is largely through adopting a scientific approach to problems that Africa would be able to join a world where science has already become a dominant cultural factor. With this desirable scientific attitude in the African, a successful war could be waged against superstition; aptitudes could be developed for vocational pursuits; the child and the adult would be able to manipulate simple gadgetry, work of hand and eye which would buttress or supplement mind and heart. It is most essential that Africans develop this scientific attitude in agriculture, still the occupation of over seventy per cent of the people.

I sincerely believe that no major industrial revolution can either take place or be sustained, no new society can be built or maintained in a continent where the masses are still dominated largely by magic and superstition. I also believe that the scientific attitude can be acquired as a way of life, in the same way as socialism, capitalism or communism is injected into the society as a way of living.

Considerable emphasis needs to be placed on science at the elementary level, because for the next fifty years or more, most African countries will not be able to provide more than a free elementary education for their people. Consequently, millions of future African citizens, who will form the bulk of Africa's man-power, will not have more than a primary education, or at best two or three years of secondary education. It follows, therefore, that this new generation of citizens should have a broad scientific background at this elementary level of education.

I am happy that this particular workshop is on "Integrated Science." This is a fashionable topic these days and it is like the weather which everybody talks about but does little about it. It is gratifying that the UNESCO and the African countries' representatives who are assembled here today are determined to do something about it.

Making a case for Integrated Science programme at the primary and the secondary school levels may be like preaching to the converted. Nevertheless, we cannot overemphasis its importance to Africa in particular. Most of us are products of specialised education and the scientists are not the only culprit in this area. It is ironical that even though we know that specialisation is meant to serve only a handful of people, educators insist on giving everyone specialised education. In the United States and the United Kingdom only a very small proportion of the secondary school and university graduates work in the area of their specialisation. Worse still, many of the graduates required by industry have to be trained or re-trained in the area required by commerce and industry. Nigeria, like many developing countries is going through the same experience. Less than forty per cent of our University graduates are engaged in the field of their specialisation. Even in the teaching field a high proportion of our graduates are teaching the subjects in which

they had little or no formal academic training. Indeed we expect this state of affairs to continue for quite some time to come.

The question has been raised at a number of international conferences as to whether the university graduate should be a specialist or a generalist. Most graduates in Britain and all of its former colonies tend to be over-specialised and like most specialists they knew more and more about less and less until they reach a point where they knew everything about nothing! Their education was so narrowly based that many of them became absolute illiterates not only in non-science subjects but also in other allied areas of science. It is rather bewildering for me to meet some Ph.D. holders in Chemistry who can only teach organic chemistry but not inorganic chemistry to first year university students or vice versa; or a Ph.D. holder in some small aspect of Zoo who cannot teach first or second year Botany. When specialisations are carried this far, then a country is in trouble, particularly a poor developing country whose resources are extremely limited both in human and natural resources. Mind you this deplorable condition obtains even in the social sciences and humanities but we must admit that science is the worst offender. In the U. S. and the U. S. S. R., specialisation is postponed till the post graduate level in most cases. Ironically, those who landed on the moon never had Sixth Form education or early specialisation!

I do not want to be misunderstood as not believing in specialisation. I recognise the ultimate necessity for specific skills. What I am advocating is a broad foundation at the primary and secondary school levels. Curiously enough we tend to forget the purpose of primary and secondary education. Both are supposed to help the child get adjusted to his immediate environment and offer him a broad general education to enable him live and act as a responsible citizen of his society. To be a versatile individual he should be exposed to the whole spectrum of education, not just a narrow experience which in any case is not really needed by industry, commerce, his home or his peers with whom he is going to spend the rest of his life. Pre-mature specialisation at primary, secondary and even at the first two years of university work is not only a disservice to a nation, it is also a national disaster, in that it is a collosal waste of limited human and financial resources of a developing country.

It is being suggested by many noted educators that even at the university level specialisation should commence at the post-graduate level. I fully agree. As for the Sixth-Form work which is the only educational exception in the world as the majority of the countries of the world have no sixth form, the British people who invested it are now seriously considering its liberalisation; that is sixth formers should be exposed to six or seven subjects instead of three as it is the case at present. As for me, I re-affirm that as far as Nigeria is concerned, it should be scrapped without further ado.

Child Inventors

In the last two years the Nigerian press carried to their credit, articles and pictures of two or three Nigerian youths who constructed their own air plane, boat and other scientific gadgets. A young man constructed an airplane that flew for ten minutes in the air before crashing to the ground; another youth made his own motor car and another a steam boat that worked. These youths either had only a primary education or one, or two years of secondary education. Ironically one is tempted to say, "Thank God, they left school before they became specialised robots who cannot see beyond their nose." I wonder aloud as to how many of us who are specialists in physics or applied physics or mathematics or engineering can construct and fly an airplane even for one minute or construct and launch a

steam-ship that will sail for ten minutes only. It is our contention that most of the world inventors never learnt half of the physics, chemistry and mathematics that we teach at the secondary and university levels today. What I am trying to put across here is that the age of passive reliance on tradition and authority without question belonged to the 19th century. The obscurantist's faith in the expert's special knowledge and skill, personal knowledge and authority is a thing of the past and cannot by any stretch of imagination get us far as developing countries. We need to widen the scientific horizon of our youths by exposing them to a wide spectrum of scientific skills and investigation with a view to developing their scientific attitude not necessarily as scientists-to-be for only a handful of them need to be scientists, but as scientifically oriented citizens of their country and their world.

Lord Beeching who is a British Physicist, is a man after my heart. In his address to the Third International Conference on Physics Education he said inter alia:

". . .(There) is the need for special care to guard against establishing an illusion of complete understanding in the early stages of teaching, with the resultant danger of creating mental blocks to subsequent acceptance of more refined theories.. In my own case, and I do not believe I was exceptional, early acquaintance with Newton's laws created such complete acceptance of them as to cause very real difficulty in my subsequent acceptance of quantum mechanics and relativity. It was not that I could not handle the mathematics, but I could not do so with any facility because I kept thinking, 'I understand Newtonian mechanics but I don't understand this', and I felt, therefore, either that my mind was inadequate or that there was something false about the concepts which I was asked to accept. It was only later, when I realised that I did not understand the phenomena which Newton's laws describe, either, but had merely accepted the laws as a complete and satisfying description of the phenomena, that some of my difficulties disappeared. I suspect that difficulties of this kind are still being created, and created unnecessarily."(1)

I wish many of us can be as frank as Lord Beeching for it is only if we can recognise our own limitation that we will be in a position to take a critically honest look at our outmoded education system and our traditional teaching method. According to many critics,

". ... the graduate scientist or technologist too often displays a narrowness of view and interests (and) is unable to relate his own work to that of his colleagues or theirs to his, or is not as effective as he should be as a member or as a leader of a team because of his inability to communicate effectively with others or to enter sufficiently well into their thoughts and feelings.".(2)

The African Child

The first twelve years is the most formative period in a child's life for it is during this period that attitudes and aptitudes are developed. It is also during this period that the child requires intelligent care of his physical needs and trained guidance in his mental, emotional and social potentialities. It is our contention that the African child like any other child should be helped right from the start to develop some or all of the following scientific skills and abilities: curiosity, manipulative ability, spontaneous flexibility, experimentation,

(1) The Education of a Physicist, Edited by S. C. Brown and N. Clarke, Published by Oliver & Boyd, London, 1966 pp. 1 and 2.

(2) Loc. cit.

initiative, industry, manual dexterity, mechanical comprehension and the coordination of hand and eye (and in passing, how we wish he could do this in his own mother tongue!). As we said earlier, most of our children in Africa will not have more than a primary or two years of secondary education before the end of this century which is only 29 years away. We want to make intelligent versatile, and scientifically oriented citizens out of them. To achieve this we need to give them a broad general science education. A few of them will become specialists but this specialism will be more meaningful only if predicated on a general science education. As I said earlier, I may be preaching to the converted and I will not bore you any further.

Integrated Science Programme

What, we may ask, are the objectives of an integrated science programme? One objective is to develop scientific attitudes, abilities and behaviour; that is, to develop a built-in scientific attitude in the child as soon as possible. As one of my colleagues expressed it, "what is integrated about science is not the topics studied but the process of studying them." (3)

I mentioned earlier some of the behavioural goals that we hope to achieve through general science education, these are; manipulative ability, spontaneous flexibility, initiative, industry, experimentation etc. The primary science panel of the Nigerian Educational Research Council (NERC) at a recent workshop let by Dr. E. A. Yoloye of the University of Ibadan adopted a modified version of the American Association for the Advancement of Science (AAAS) process classification scheme for building new science curricula for Nigeria. The fifteen behavioural goals, while not exhaustive, should serve us in good stead in determining some of the skills and attitudes we wish to build into the personality of the child at the end of an integrated science course:

1. **OBSERVATION**

   All experimental science involves observation of natural and man-made phenomena. These observations can be made in a broad descriptive sense, or they may be associated with indepth examinations of limited specialized systems.

2. **CLASSIFICATION**

   This process is found in some degree in almost all scientific activities. Sorting, grouping, and ordering, both on a qualitative and quantitative basis, fall into this category.

3. **COMMUNICATION**

   Once experience with "scientific" materials has been acquired, the ability to communicate regarding observations, data, discoveries, etc. is fundamental to the growth of scientific knowledge.

*4. **COUNTING NUMBER RELATIONSHIPS**

   The first level of quantification in science is the application of counting number to observations. The use of discrete number, in association with units of measure . . . 5 trees, 9 stones, etc., is the beginning of measurement. In science, number is always associated with a unit of measure, and the counting operation forms the basis of a wide range of quantitative observations.

(3) E. A. Yoloye, Journal of the Science Teachers' Association of Nigeria, Vol. 10, No. 1, 1971, p-64

ERIC

**5. MEASUREMENT

Once one passes from the operation of discrete counting of isolated objects, a new form of measurement is identifiable. Man-made units of area, length, volume, and time are describable on a continuum, with number itself assuming a relative role. In a sense, almost any number system can be imposed on this type of measurement, as long as it is consistent from one unit to the next. Congruence of unit is the single criterion to be applied within a given measurement system of this type.

6. RAISING QUESTIONS

Inherent in any subject matter scheme involving direct observation and experimentation is the richness of questions arising directly from the exposure of individual pupils to the materials. Thus, in observing several pendulums of different lengths, one might ask why do they move at different "speeds".

7. PREDICTION

The process of prediction proceeds from well-founded bases of hypothesis, theory, or "laws". Once a collection of consistent data is obtained, such operations as extrapolation and interpolation form the basis of this important scientific process. The importance of prediction to scientific enquiry is that science places greater emphasis on the ability to predict (in its process of knowing) that on the ability to describe or explain.

8. INFERENCE

This is a broad category of process. It implies cause and effect relationships and correlations. One is exposed to observation of several variables which seem to be related and one infers a relationship between them. Inference may be speculative, based upon preliminary or sketchy data, or it may be more well-founded, based upon extensive and precise data obtained from experiments.

9. FORMULATING HYPOTHESES

Almost any series of observations can lead to hypothesis formulation. Hypotheses need not be too profound or have a high probability of experimental verification, as long as they arise from observations which lead one to speculate as to what will happen if . . . .?

10. MAKING OPERATIONAL DEFINITIONS

Oftentimes in experimentation it becomes necessary to describe phenomena in concrete terms without complete or exact knowledge of what is actually happening. Here the emphasis is on setting boundary condition with reference to "activity" observations which enables one to "go on" with a working definition, subject to later revision, without less of validity.

11. CONTROLLING OR MANIPULATING VARIABLES

Measuring variables is one thing. Controlling or manipulating variables is quite another. Here the emphasis is on identifying variables in a system, holding some constant, and manipulating others, usually only one, to see how the system functions. Discovering the relational role of a variable in a system is the highest level of understanding in this process.

** Differentiation between counting number relationships and measurement proper is usually obvious, but there are "grey areas" where the two merge imperceptibly.

12. **EXPER[illegible]ENTING**

In a primitive sense, experimentation may take the form of trial and error activities, based upon previous experience. At its higher levels, however, experimentation means probing along a path that appears fruitful. In the strictest sense, experimentation implies the test of hypotheses formulated on the basis of experience gained in previous experimentation.

13. **FORMULATING MODELS**

Mental models are built to encompass many related observations. One builds these models to "picture" what is happening now and to predict what will happen in another set of circumstances. One of the chief characteristics of this process is the continual change and refinment of the model in the light of new evidence which challenges some facet of the model.

14. **INTERPRETING DATA**

The collection and classification of data is not often an end in itself. A more important aspect is, "what does the data tell you?". Data, should be analysed with the aims of generalising where possible, utilizing the data as a basis for prediction, and considering the "quality" of the data in terms of designing more refined experiments. The interpretation given to a set of data provides the impetus for new investigations.

15. **MANIPULATIVE SKILL**

The acquisition of mechanical skills of manipulation is fundamental to the creation of situations in which the other processes are naturally brought out. Increasing manipulative skill means the use of more and better apparatus with the increasing probability of requiring the other processes for explanation or understanding.

I suggest that this august body consider these fifteen points as examples of some of the ways we can approach the designing and the teacher of an integrated science programme for primary and secondary schools.

For too long in Africa, we have been educating too many people with educated head and uneducated hand; we need to educate the new generation of African children to use their head and hand very effectively.

How do we broaden the background of our children to enable them react confidently to their environment? I suggest that we need to discover the intimate connections that exist among disciplines as well as look for all possible extensions. To cite a few examples of what I have in mind: One would like to have a science unit entitled: "Elements of automatic control in plants, animals and plant behaviour." In plants and animals, ecology, anatomy, evolution physiology, genetics etc. are common phenomenon to both. Why not exploit and extend these to the nth degree?

I am sure our scientists here at this Workshop are up to the task and the next few days should give us a good start.

Functional Agriculture, Health and Nutrition

On agricultural science, nutrition and health, these are best taught by examples rather than by precepts. Teachers and pupils must be fully involved and the best involvement is through active participation by both. Children are more interested in cause and effect rather than a study in depth of reproduction cycle of a mosquito. They want to find out by themselves what happens when plants are deprived of air, water and light and in how to make bigger and better yams, tomatoes, oranges, corn etc. Above all, they want to do it themselves. They need to experiment with their own plots and try their hands on cooking and in making delicious dishes. In other words, teaching of agriculture, nutrition and health should be functional and practical. Theory without practice is like learning to swim by correspondence!

We must select the appropriate learning experiences that will help in achieving our identified aims and objectives for the integrated science programme. First we must realise that the majority of our children will not go on to the secondary grammar school for some time to come. But all of them will be citizens of their countries and most of them will in the meantime become apprentices, farm hands, petty traders, and the like. We need literate farmers, carpenters, traders etc. Above all, we need good, proud and honest citizens– thus we need this type of person in Africa today more than doctors, lawyers, teachers etc. In any case, if we produce good citizens, they will become good lawyers, good teachers, good doctors, good farmers, good carpenters or good scientists. In identifying the learning experiences required, we ourselves as teachers must realise that:

(a) learning is an active process and the learner must be actively involved;
(b) learning becomes more effective if the learner understands what he is learning;
(c) environment affects learning;
(d) teachers affect learning;
(e) individual differences affect learning;
(f) values, goals and motives affect learning;
(g) all learnings are multi-purpose;
(h) reinforcement is essential in learning;
(i) integrated learning experiences yield better results.

The child we plan to educate must by the end of our course be flexible, responsive, sensitive. He must by attitude and learning be willing to explore new phenomenon and seek more knowledge on his own.

The teachers Africa needs are those who are humble, flexible, inquisitive and responsive to the needs of their children.

They must be willing to explore new phenomena with their children and seek more knowledge on their own. They must above all be willing to experiment and be unafraid of failure. (4)

Whatever we do as teachers and administrators, it is incumbent upon us to create the suitable environment that will enable the child discover things for himself.

As a popular saying goes, there are three kinds of people:

(1) A few who make things happen
(2) Some who watch things happen
(3) and millions who don't know what is happening.

I hope that the few of us who are here at this Workshop will make things happen in Science Education in Africa.

(4) A. B. Fafunwa, New Perspectives in African Education, Macmillan & Co. Ltd., p. 163.